SPECIAL BULLETIN NO. 25 MARCH, 1904

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STATE AGRICULTURAL COLLEGE
EXPERIMENT STATION

BOTANICAL DEPARTMENT

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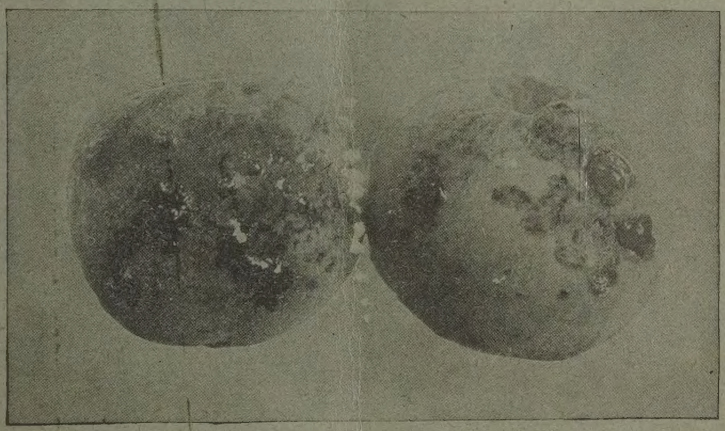

BY

B. O. LONGYEAR, BOTANIST

AGRICULTURAL COLLEGE, MICHIGAN
1904

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MICHIGAN AGRICULTURAL EXPERIMENT STATION

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FUNGOUS DISEASES OF FRUITS IN MICHIGAN.

The necessity of systematically combating the diseases which affect the orchard and its product is so generally recognized at the present time by the progressive fruit grower, that it seems scarcely necessary to urge the importance of this matter in his case. In fact the spraying and other treatment of his trees by the professional fruit grower forms a regular part of each season's work, and any information which leads to a clear understanding of the agencies of disease is sure to be appreciated by such a person as enabling its possessor to do this work more intelligently, therefore more successfully. In spite of the vast amount of information along this line which has been published during recent years there is still a considerable lack of knowledge of the true nature of the common diseases to which orchard fruits are subject. Thus the general farmer who grows fruit as one of several products is too often without a proper understanding of these matters, consequently his trees are usually allowed to take care of themselves. The result is very evident in the diseases which appear. The leaves, the organs of respiration and assimilation, become spotted and unhealthy or perhaps shrivel and fall off; the branches die back; the trunks are scarred, cankered and decayed; and the fruit while diminished in quantity is often of so poor a quality as to seriously injure its market value and keeping qualities. The serious losses in the case of barreled apples which were badly affected with scab has led the apple buyers in some portions of the state to refuse the fruit from orchards which have not been properly sprayed and tended. Thus in such instances the loss consists not merely in the diminished crop of poor quality but also in the absence of a market for the fruit.

While a great deal of information relating to plant diseases and their treatment has been printed in bulletins and agricultural papers it is so scattered that the majority of persons engaged in fruit growing in this state doubtless find it somewhat tedious to find this information when wanted on short notice. Consequently this bulletin is intended to serve as a sort of text book of the diseases most common and destructive to fruits in Michigan. Technicality has been avoided as much as possible, the attempt being made to give clear and readily comprehended descriptions of each disease together with the most approved methods of treatment. The information has been gathered wherever the most satisfactory accounts of diseases and their treatment could be obtained. The publications of the U. S. Department of Agriculture and the bulletins of the various State Experiment Stations have furnished the greater part of this matter. This bulletin, however, is not a mere compilation. Most of the figures are from original drawings and photographs and represent actual speci-

mens studied by the author. Also personal observations of the principal diseases and the more common methods of treatment have been made.

COMMON CAUSES OF PLANT DISEASES.

Plants may be diseased in several ways. In fact the condition brought about by anything which disturbs or prevents the carrying on of the normal functions of a plant or any of its organs may, in a general way, be considered a disease. The most common diseases of plants are now known to be due to the attacks of parasitic organisms such as bacteria and fungi. Fungi, however, constitute the commonest of the causes of diseased conditions in plants.

Fungi themselves are plants of a very low order and are quite simple in structure as compared with plants which bear leaves and flowers. Most of the flowering plants possess leaves which contain a green coloring matter (Chlorophyll) which enables them in the presence of sunlight to assimilate the raw food materials of the soil and air and thus to grow. Fungi, however, do not possess this green coloring matter, hence are forced to depend on organic substances such as rotting leaves, wood, straw, manure, and the humus of the soil (Saprophytic Fungi) or on the tissues of living plants (Parasitic Fungi). Familiar examples of the former are seen in the common mushrooms and the shelf or bracket-like fungi which grow on decaying stumps and logs. (Fig. 41.) These are mostly plants of considerable size some of them being valued for food. The fungi which exist at the expense of living plants, however, are mostly very small organisms and require the use of the microscope in studying them. They make up however, in numbers and rapidity of growth for their insignificant size, consequently these parasitic fungi are able to cause incalculable injury to cultivated crops each season.

In its early stages of growth a fungus consists of a delicate mass of cobweb-like threads which branch in all directions in search of nourishment in very much the same manner as the fine rootlets of other plants. This network of slender threads is known as mycelium or spawn and serves the purpose of root and stem. It may be found at almost any time by overturning old boards or decaying leaves lying on the ground. In the case of the parasitic or disease producing fungi the mycelium invades the tissues of the plant on which it lives (known as the host plant) and causes in some cases swellings and distortions of the affected part, or in other cases the cells of the host plant are killed as soon as attacked, thus leading to the death of the diseased organs or of the entire plant. In some cases, however, the mycelium lives on the surface of its host merely sending little sucker-like branches into the affected part as in the powdery mildews.

SPORES.

Fungi are reproduced and spread by means of minute bodies called spores. Spores may be formed in a variety of ways after the mycelium becomes established. The most simple method is that in which the mycelium gives rise to branches which bear one or more spores at the apex or along the sides, or, in some cases, the branch itself becomes changed into a chain of spores by the formation of little partitions or septa, the cells thus formed finally separating from each other and each consti-

tuting a spore. More complex methods usually consist of the formation, by the mycelium, of fruiting bodies often dark in color, which are hollow and either give rise to spores from the inner surface directly or to small spore sacks (asci) each containing a number of spores which when mature are discharged by the breaking of the surrounding wall.

Spores are so small and light that they can readily float in the air for some time as an almost invisible dust and may also be carried on the bodies and feet of birds and insects. In some cases they are produced in such enormous numbers as to form a cloud of smoke-like dust when disturbed, as in the powdery masses of corn smut. Some idea of the amazing number of spores produced by such a fungus may be gained only by knowing their measurements. Thus a mass of such spores the size of an ordinary match head could contain about ten million of these microscopic bodies, enough to cover an acre and a half at the rate of one spore to the square inch.

When the spores of fungi are surrounded by favorable conditions of moisture and heat they may germinate usually by pushing out a slender germ tube. In the case of the parasitic fungi this germ tube enters the tissues of its host plant and forms the beginning of the mycelium. In this manner the host plant becomes infected. A great many fungi possess two forms of spores. One kind, known as summer spores, is produced in great abundance during the growing season. They are capable of germinating as soon as mature and thus serve to spread the disease from one plant to another. The other kind of spores, known as resting or winter spores, is formed usually late in the season and remains over winter in a dormant condition often in or attached to the dead tissues of the host plant. When spring arrives and the host plant is pushing out its first tender growth these resting spores germinate and thus start the disease anew.

In the case of some parasitic fungi the mycelium is perennial in the stems of the host plant remaining dormant during winter but becoming active again the next spring, as in the leaf curl fungus of the peach and the black knot of the plum.

DISEASES OF THE APPLE.

APPLE SCAB.

(Venturia Pomi (Fr.) Wint.)

Fig. 1.—Apple leaves affected with the Apple scab fungus. (Original.)

The disease of the apple commonly known as "scab" or in some cases "black spot," is probably familiar to every grower of this fruit. It first appears in spring on the young foliage producing velvety, olive colored patches. This form is sometimes known as "mildew" or "leaf blight." In severe cases the leaves become shriveled and discolored, eventually falling off. The fungus also attacks the stems of the young apples at blossoming time, especially if the weather at this time is unusually cool and moist. This causes the young fruit to shrivel and drop off, often greatly reducing the crop of mature fruit.

The most characteristic effects of this fungus parasite, however, are found on the fruit itself. Here the spots at first appear much like those on the leaves but as the fruit develops the fungus works under the cuticle or outer layer of the skin causing it to scale off. These spots on mature apples have a dark brown or blackish color with a narrow border of a light gray color. The spots are usually most numerous around the blossom end of the fruit. On badly affected fruit the spots run together sometimes covering one third of the surface. Deep cracks often occur in such cases which allow the apple to dry out.

Apple scab is without doubt the worst disease affecting this fruit. This is due not alone to its destruction of the foliage and young apples nor to the unsightly spots which it causes on the mature fruit. In addition to all this it opens a way for the entrance of numerous rot-producing fungi into the tissues of the mature apple. Thus during the seasons of 1902 and 1903, which were characterized in this state by an unusual rainfall, great quantities of apples were lost soon after packing and in storage and even during shipment through the agency of these soft rots following apple scab. In some cases reported apples affected with scab began rotting while still attached to the trees, the loss in some cases amounting to four-fifths of the entire crop.

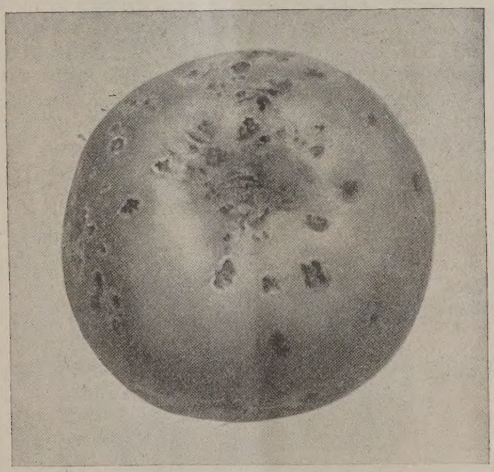

Fig. 2.—"Scab" spots on an apple. (Original.)

Among the fungi which produces soft rot of apples and which usually attack the fruit where scab exists, the following have been noted as most common in this state:

Cephalothecium roseum.
Penicillium glaucum.
Sclerotinia fructigena.
Mucor stolonifer.

PREVENTION AND TREATMENT.

The fungus of apple scab thrives during moist cool weather, consequently the disease is apt to be most prevalent during seasons when such weather prevails especially during the early part of summer. Fruit grown on closely crowded trees where air and light are shut out appears to be more severely affected than where the opposite conditions prevail. Therefore a location securing good ventilation, proper spacing of trees, and systematic pruning are to be considered as preventive measures in the case of this disease. It has been found that the fungus passes the

winter on the fallen leaves, appearing as minute. black bodies buried in the leaf tissues. From these are given off in the following spring the first crop of spores which attack the lower leaves, the disease later spreading to all parts of the tree. Thus another preventive measure is suggested and recommended, viz.: the destroying of these dead leaves which serve as agents of infection. This may be done either by raking and burning them or by plowing them under in spring before the spores are shed.

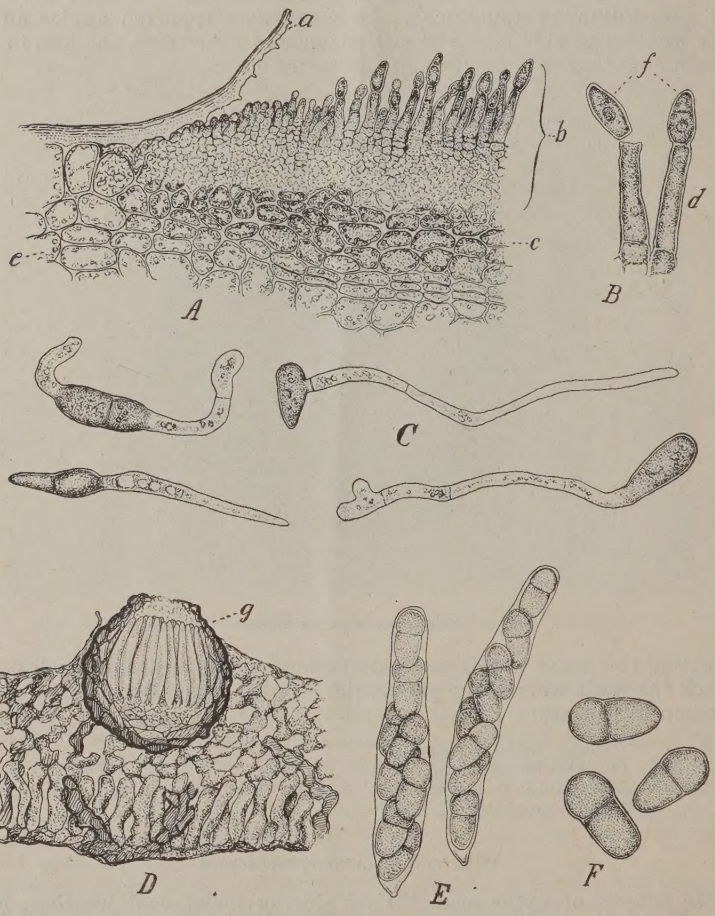

Fig. 3.—Microscopic structure of the scab fungus. A, portion of a section through a scab spot on an apple showing the fungus, (b) spreading under and lifting the cuticle, a: c, partly disorganized cells of the apple; e, healthy cells of the apple. B, two spore-bearing stalks (conidiophores) giving rise to summer spores (conidia) f: C, spores germinating; D, portion of section through an affected leaf of apple which has lain on the ground over winter and has given rise to the winter spore stage of the disease. g, spore case (perithecium) containing a bundle of spore sacs (asci); E, two spore sacs (asci), more highly magnified, each containing 8, two celled winter spores three of which are shown at F. All highly magnified. (Original.)

The planting of varieties which are naturally less subject to the scab is also to be considered as a preventive measure. Spraying for the prevention and treatment of this disease has proven of unquestioned value and a paying investment to the apple grower. The first application made before the buds open may be the copper sulphate solution (*A*) which is cheaper and easier to prepare and use than Bordeaux mixture. By many growers this application is considered the most important one for fungous diseases and should not be neglected. At this time great care should be used, to avoid driving on the soil when full of water especially if it contains much clay as it is apt to become puddled thereby and its texture much injured. After the leaves appear, however, it will be necessary to use Bordeaux mixture, the first application of this spray to be used just before blossoming. This is the most important treatment of the season. The second after the blossoms fall and two or three other applications at intervals of ten days to two weeks will prove beneficial, especially if the season is a wet one. The final spray may consist of the weak solution of copper sulphate B to avoid staining the fruit.

BITTER ROT, RIPE ROT, ANTHRACNOSE.

(Glomerella rufomaculans Von Schrank & Spalding.)

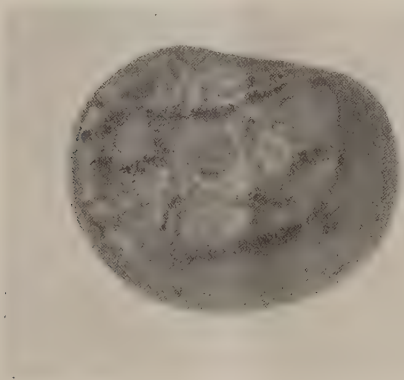

Fig. 4.—An apple decaying with the bitter rot fungus the affected portion showing pinkish spore pustules.

Like the black rot the bitter rot is most prominent on the fruit. Infected apples show brown spots which rapidly enlarge until the whole fruit is involved. Small pimples soon appear in concentric order around the points of infection. From these pustules the spores ooze out, showing a pinkish color in mass, and are washed on to other apples by rain, or becoming dry, may be carried away on currents of air. A resting-spore stage is also known to occur on apples which have rotted with this disease, and this is one means by which it is carried through the winter. An investigation of the disease of bitter rot conducted by Von Schrank and Spalding in 1901 and 1902 revealed the fact that the chief source of infection arises from a permanent or winter stage of the disease in the form of cankers on the limbs of the apple tree.

Apples affected with this disease commonly possess a bitter taste although this is not always the case.

Bitter rot is very destructive in some of the more southern states, being especially bad in Southern Illinois where it is the chief apple rot. Its presence in Michigan has been noticed as somewhat uncommon. The writer has found it on Pennock's red stored in a cellar and on packed Greenings. Ben Davis and Grimes' Golden are recorded as varieties most subject to this disease in Illinois. This fungus also occurs on the grape, pear, peach, quince and even on tomatoes.

The preventive measures and other treatment for this disease are practically the same as for the black rot fungus. Destruction of old diseased fruit and the removal of cankered limbs wherever found are to be practiced. Spraying to be successful should be begun before the disease appears.

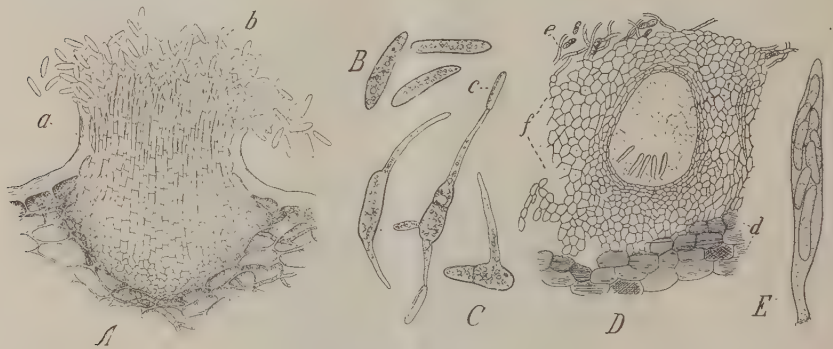

Fig. 5.—Microscopic structure of the bitter rot fungus. A, section through the affected part of an apple. The mycelium of the fungus has formed a mass of spore bearing stalks (conidiophores) which have ruptured the epidermis of the fruit and formed a pustule from which numerous summer spores (conidia) are being given off; A, cuticle of apple; b, spores: B, spores (conidia) more highly magnified: C, spores germinating in water. Two of them have become divided (septate) and one has formed secondary spores, c, on the germ tubes; D, section of an old affected apple showing the permanent winter stage of the fungus; d, cells of the apple on which is seated the thick walled spore case (perithecium), f, in which young spore sacs (asci) are forming; e, mycelial threads among which are scattered some two celled spores (conidia): E, a mature spore sac, (ascus) containing eight spores, (ascospores). All highly magnified. (D, E, after Burrill, the others original.)

BLACK ROT.

(Sphaeropsis malorum Berk.)

Black rot is a common disease, especially on fruit of summer and fall varieties of apples. These are attacked usually when nearly mature and often while still hanging on the tree. Apples affected with this disease decay rapidly becoming brown at first, with blackish discolorations under the skin. As the disease progresses the black color spreads until the fruit may become entirely blackened. The apples retain their firmness for some time, and then gradually dry out becoming much wrinkled and shrunken. Just under the skin of such apples small black dots or pus-

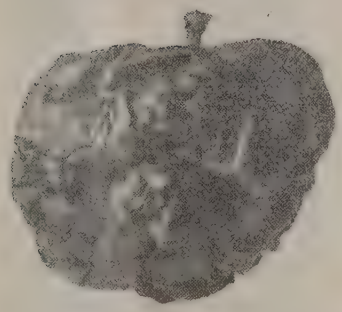

Fig. 6.—An apple affected with the black rot fungus showing the wrinkled condition and dark color of the dry fruit which is often found hanging on the trees or lying on the ground over winter.

tules may be seen even with the unaided eye. They are the spore producing bodies of the fungus. A section through one of these bodies (Fig. 8) shows it to be hollow with a projecting mouth from which the oval or egg-shaped spores escape. This fungus, however, is not confined to the fruit alone. In 1899 Paddock at Geneva, N. Y., demonstrated that it is the cause of a canker on the branches of the trees. Previous to that time these injuries were ascribed to sun scald but it is now definitely known that the black rot fungus is the true cause. Its first effect on the branches, which are attacked in the spring, is shown by a discolored area of the bark. These areas gradually enlarge killing the inner bark and later showing a definite boundary at the margin of the dead portion. Spore producing bodies form in these diseased areas. In time the bark becomes loose and rough or sloughs off exposing the bare wood. In severe cases limbs may be completely girdled when all that portion beyond the canker dies. The fungus apparently gains an entrance through cracks or wounds and seems to prefer large branches although it also occurs on twigs. For this reason and because of its obscurity this disease is capable of doing much injury to the trees before its presence is detected. The leaves are also affected by the black-rot fungus which causes the appearance of brownish spots and may lead to the premature shedding of the foliage.

Fig. 7.—Two young trees showing cankers due to the black rot fungus and produced by artificial innoculation by Paddock. a, Pear; b, apple. (Original.)

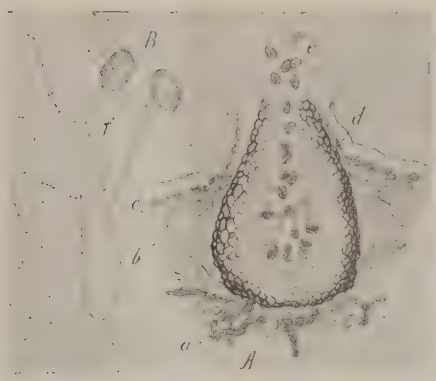

Fig. 8.—Microscopic structure of the black rot fungus. A, section from a wintered specimen of crab apple showing, a, the dark colored mycelial threads among the cells of the fruit, b; d, a thick walled spore case, (pycnidium), which has pushed through the epidermis, c, and is giving off dark colored spores, e, through the protruding mouth: B, mature spores germinating in water and giving rise to germ tubes, f. All highly magnified. (Original.)

TREATMENT.

Collecting and burning or burying the diseased fruit late in autumn will greatly diminish the number of spores of this fungus and consequently the liability of infection as the spores are given off from these affected apples. The spraying methods used for scab will also serve to check this disease. Cankers on large limbs should be scraped, painted with the copper sulphate solution A and coated with tar or paint. Smaller branches should be cut off below the cankered area and burned.

TWIG-BLIGHT, FIRE-BLIGHT.

(Bacillus amylovorus (Burr.) DeToni.) (See Pear.)

CANKER.

Canker is a general term applied to diseased areas in the bark and wood of the stem and branches of trees and causing more or less deep-seated killing of the tissues. Such areas usually appear roughened by the scaling or cracking of the bark or they may protrude in the form of knotted swellings. When the bark sloughs off the margins of the canker often show the attempt of the tree to heal the wound by the formation of a roll of new tissue. Several different fungi have been found to be the cause of cankers of the apple tree. They are mostly wound parasites. Experiment Station Bulletin No. 70, University of Illinois, 1902, discusses the principal fungi causing these cankers. (See also Black-Rot.)

Badly cankered limbs might better be entirely removed and burned than to attempt to save them. Cankers may often be healed by scraping or cutting away all diseased bark and wood and treating with sulphate of

copper wash, and later coated with tar or paint. Spraying the trees as for scab will tend to prevent attacks from canker-producing fungi of the apple.

SOOTY BLOTCH.

This is of quite common appearance on the surface of apples which seem to have small patches of soot dusted on them. It is known to be of fungous origin and while not injurious, produces an unsightly effect. Among the varieties most affected are mentioned Greening, Northern Spy and Baldwin. It also attacks pears, especially Anjou and Lawrence. The Bordeaux spray successfully checks this fungus.

LEAF SPOT.

(Phyllosticta pirina Sacc. & P. limitata Pk.) (See Pear.)

POWDERY MILDEW.

(Podosphaera oxyacanthae (D. C.) D. Dy.)

This fungus lives on the surface of the leaves and sometimes causes trouble especially to seedling apples in the nursery. Prevented by spraying with Bordeaux.

RUST.

(Gymnosporangium Spp; roestelia stage.)

Rust affects the leaves causing yellowish spots in which are located the spore bearing organs of the parasite. The spores, which are of an orange color, attack the twigs of the red cedar, causing swellings, the so called cedar apples. Another spore form from these "cedar apples" infects the leaves of the apple causing the orange rust. This disease is quite injurious in some of the eastern and southern states but is not prevalent in this state. Paddock also reports a rust of the same nature on the quince in Colorado. Cutting the cedar trees which may be adjacent to affected orchards will tend to prevent this fungus from becoming troublesome.

FRUIT SPOT.

(Phyllacora pomigena (Schw.) Sacc.)

Fruit spot is not an uncommon trouble, especially on Baldwin apples. It appears in the form of small circular, slightly sunken spots of a brown color. This brown discoloration usually extends only a little way into the flesh of the fruit and possesses a bitter taste. For this reason it is often confounded with the bitter rot fungus. The diseased spots give rise to spore producing pustules if the conditions are favorable. This disease has been greatly reduced by spraying as for scab.

PEAR DISEASES.

PEAR SCAB.

(Fusicladium pirinum (Lib.) Fckl.)

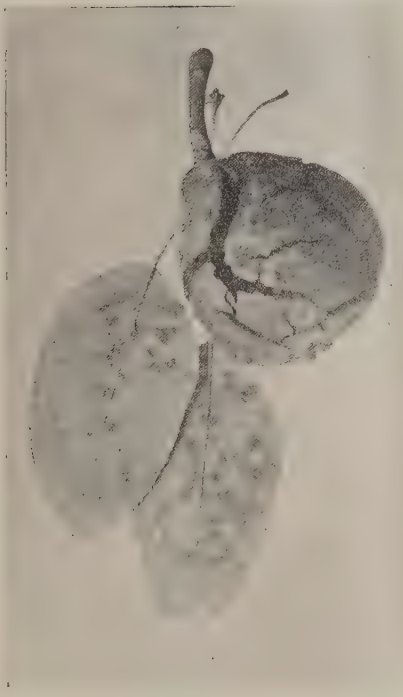

Fig. 9.

Fig. 11.

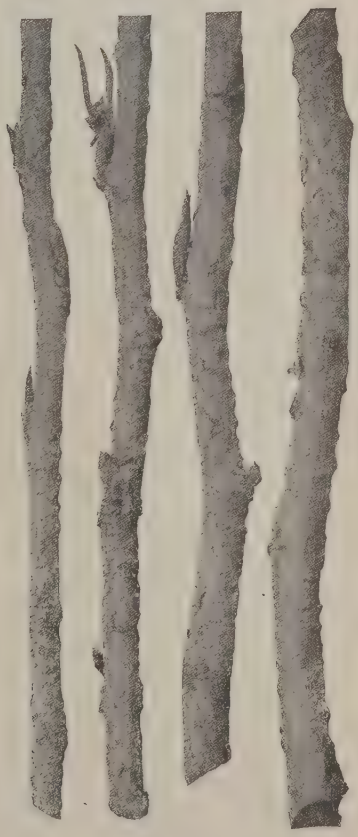

Fig. 10.

Fig. 9.—Fruit and leaves of Doyenne pear affected with pear scab. (Original.)
Fig. 10.—One year old shoots of Flemish beauty pear affected with the scab fungus. (Original.) Some of the spores taken from these branches eight months after they were cut germinated when placed in water.
Fig. 11.—Spores of the pear scab fungus highly magnified. (Original.)

Pear scab is so similar in appearance to the scab of apple as to hardly need other description. It attacks branches, foliage and especially the young fruit. In the latter case the pears soon fall off or if they mature are often worthless. Flemish Beauty seems especially subject to this disease as are also Seckel and Summer Doyenne. Young branches of the last variety, sent to the writer, have presented a superficial appearance much resembling that of a scale insect. The outer bark on such stems rounds out in small, sharply defined swellings usually with a ruptured center. The presence of the spores of "scab" indicate the fungous nature of these spots.

The same line of treatment accorded to the apple scab is indicated for this disease. The planting of varieties less subject to the scab than the above mentioned kinds is also desirable.

LEAF BLIGHT.

(Entomosporium maculatum Lev.)

The fungus causing this disease attacks the leaves and fruit of the pear and quince. On the leaves it produces small rounded spots of a brownish-red color. On the fruit the spots soon lose their reddish color becoming much darker, while the surface sometimes becomes cracked in severe cases as with the scab. In the center of the diseased spots small pimples may be seen due to the formation of spores beneath the epidermis. Later these cracks open allowing the spores to escape.

The spores themselves are very peculiar, each being composed of two large and several small cells united and possessing several bristle-like processes giving them an appearance suggesting some kind of an insect.

So far as the writer has ascertained this disease is not so common in this state as those farther south and west. It is sometimes especially bad on nursery stock in the row.

It is quite readily controlled by the Bordeaux mixture, about three applications serving to keep the foliage and fruit free from the disease.

BLACK ROT. (See on Apple.)

This disease also sometimes appears on the pear and is capable of inducing a rot of the fruit as well as a canker on the branches.

LEAF SPOT.

(Septoria piricola Desm.)

This disease is of considerable importance in the pear orchard. It attacks the leaves producing numerous small dead spots of a greyish color. Under a hand lens these spots are seen to have a number of small black bodies buried in the tissue of the leaf and from these bodies issue the spores of the fungus. While each diseased area in the leaf blade may seem of little importance yet their great number often causes the leaf to

Fig. 12.—Pear leaves affected with the leaf spot fungus. (Original.)

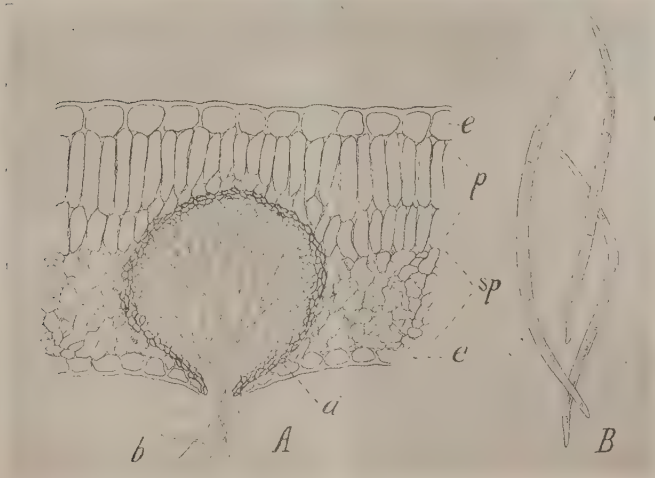

Fig. 13.—Microscopic structure of the leaf spot disease of pear. A, portion of a section through a leaf spot, showing e, e, spidermis of the leaf; p, palisade cells of leaf; sp, spongy parenchyma of leaf; a, a spore case, (pycnidium), giving out spores, b: B, spores highly magnified. (Original.)

die and fall off. This early stripping of the foliage from the tree, often occurring in August, serves as a check to the further growth and the proper ripening of the buds and shoots. This untimely removal of the leaves may also cause the trees to push out another growth too late in the season to properly mature thus favoring winter killing and weakening of the tree.

TREATMENT.

Spraying with Bordeaux mixture has proven an effectual protection against this disease. About three sprayings are sufficient, the first just after the petals fall, the second and third at intervals of about two weeks.

PEAR-BLIGHT, FIRE-BLIGHT, TWIG-BLIGHT.

(Bacillus amylovorus Burrill.)

This disease is known to be of bacterial origin. It attacks the young, tender growth of apple, quince and pear and has also been recorded as attacking raspberry and blackberry shoots. Paddock, in a recent bulletin, describes a blight of apricots which also proves to be due to the same organism. Its worst effects, however, are seen on the pear. Its first appearance is indicated by the killing of the leaves at the ends of growing shoots, the leaves often presenting the appearance of having been scorched. The shoot is also affected and like the leaves may become blackened, the young wood and inner bark being much darkened. The disease progresses rapidly backward into the branches and in time may kill the entire tree. Small drops of a gummy liquid often ooze out of ruptures in the bark of young affected shoots and this liquid contains myriads of the microscopic bacteria which are the cause of this blight. Bees and other insects often feed on this material and when they subsequently visit the flowers some of the germs of the disease may be deposited on the stigmas, thus introducing them into the tissues of the tree at these points. The bacteria also gain an entrance through wounds or insect punctures but are unable to enter the uninjured stems or leaves.

The rapid progress of the disease calls for immediate attention in order to prevent the great damage of which it is capable. So far no remedy has been found to prevent or cure the blight on an affected tree by means of spraying. The only effective measure seems to be the removal of the affected branches, cutting far enough below the the limits of the disease to remove all the bacteria from the limb. Thus it is best to cut the branch off at least three or four inches below the lower limits of the disease, the removed branches being burned. This pruning should be done whenever the disease appears and a thorough removal of every affected branch during autumn is especially recommended, as the disease may otherwise pass the winter in the wood and appear the following spring. The fire-blight does not seem to prove as fatal to the apple tree as to the pear, in fact apple trees often outlive the attacks of this parasite. It is most destructive in the case of rapidly growing trees in which the wood is soft and watery, hence conditions which favor a slower and firmer growth tend to prevent or check the disease.

QUINCE DISEASES.

The quince which is closely related to the pear and the apple is also subject to some of the same diseases as those fruits.

FIRE-BLIGHT. (See on Pear.)

This disease is not uncommon on the quince and in severe cases kills nearly all of the new growth. The leaves become uniformly brown or black, this character distinguishing the disease from the leaf blight-fungus which causes spotting of the foliage. The same vigorous treatment is needed here as in the case of the pear, namely,—cutting off and burning all affected branches, care being taken to cut below the diseased portion.

LEAF-BLIGHT, FRUIT SPOT.

(Entomosporium maculatum Lev.) (See on Pear.)

This is the most common disease of a fungous nature which affects the quince. Its appearance on the leaves and fruit is similar to that on the pear. In severe cases it causes the premature falling of the foliage thus checking the normal development of the fruit.

Treatment is the same as for pear.

QUINCE RUST.

(Gymnosporangium aurantiaca Pk.)

The Quince Rust, also known as the orange rust of the quince, attacks the stems and young fruit causing swollen orange colored spots from which protrude small cylindrical processes. These tubular outgrowths are filled with dust-like orange colored spores which are carried by the wind. Another form of this disease occurs on the red cedar like that of the orange rust on the apple. The spores given off by the "cedar apple" stage infect the quince while the yellow spores produced on the quince cause the formation of the swellings on the cedar, the so called cedar apples. Thus the disease is to be feared only where there are cedar trees near the quince orchard. Instances are recorded however in which the spores from the cedar apples have been carried a distance of eight miles.

Spraying with fungicides has been found only partially successful. The removal of nearby cedars is recommended especially if the brown knot-like swellings are found on their branches. All diseased quince fruits and cedar knots should be destroyed. Early spraying of both the quince and nearby cedars with Bordeaux mixture, if the latter are to be left standing, should be tried.

PALE ROT OF QUINCE.

(Phoma Cydoniae Sacc.)

The quince pale rot is distinguished by the formation of at first a pale spot which rapidly enlarges until the whole fruit becomes softened. The spots later assume a pale blue color while the skin wrinkles and becomes ruptured, the spores of the fungous disease being discharged from spore-cavities formed under the skin.

Spraying with Bordeaux mixture will serve to check this disease. All fruits which have rotted should be removed and burned.

BLACK ROT.

(Sphaeropsis malorum Pk.)

RIPE ROT, ANTHRACNOSE.

(Glomerella rufomaculans Von Schrank & Spalding.)

These diseases are both common to the apple and are described and treated under that head.

SOFT ROT, RIPE ROT, ROT OF FRUIT.

Soft rot is a general term often applied to some of those fungi which cause a decided softening of the fruit on which they work. There are a number of these fungus rots which affect apple, pear, quince, etc. They are mold-like plants which attack ripe fruit usually gaining an entrance into the fruit through wounds like those caused by the apple scab or by means of worm holes and other ruptures of the skin of the fruit, and also through the lenticles. They usually work rapidly soon changing the fruit into a soft juicy mass, more or less covered with the spore bearing tufts of the fungus. The spore production of some of these fungi is simply marvelous and it is largely due to this fact that these decaying fruits become a source of infection for the rest of the crop. These rots thrive especially in a moist, warm atmosphere and it is under such circumstances that they do the most harm. Cold, dry air, on the other hand, prevents the germination of the spores and thus retards the growth of the mycelium of these fungi and for this reason cold storage has been found to offer a valuable means of keeping fruit.

BLUE MOLD.

(Penicillium glaucum Link.)

This fungus is one of the most common of the molds which attack the apple and pear and is also often found on ripe grapes. It is distinguished by the bluish or greenish-blue powdery tufts which appear on affected fruit. These tufts give off spores in enormous numbers, a single one of which may be the cause of an infection. It is perhaps the most common cause of the rotting of apples stored in the cellar.

Fruit Mold (*Mucor Stolonifer Ehrenb.*), Fig. 16, B, is less common than the above but is frequently seen on apples, pears and a variety of substances of organic nature. It forms many dark colored threads which bear at the apex small blackish spore cases of a spherical shape.

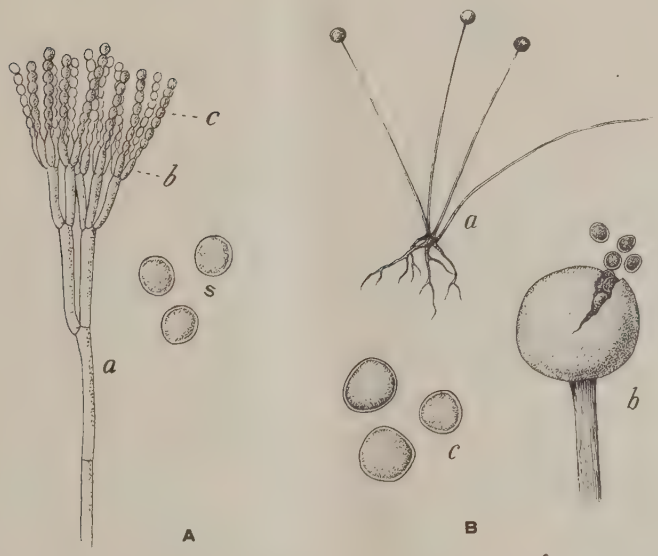

Fig. 14.—Blue mold fungus (in part), highly magnified, showing a branched spore-stalk, (conidiophore), a, producing chains of spores (conidia), c; b, basidia: s, three spores more highly magnified. B, The fruit mold, (in part), a, the common spore form of this fungus consisting of minute stalks each bearing a globular, black spore case (sporangium), at its apex, somewhat magnified: b, sporangium breaking open to discharge its spores: c, mature spores, very highly magnified. (Original.)

PINK MOLD.

(Cephalothecium roseum Corda.)

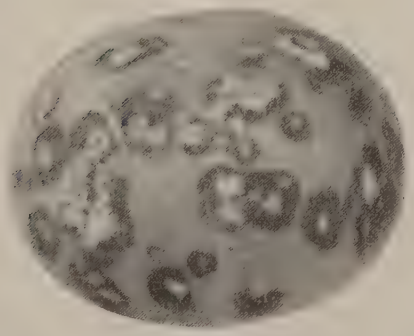

Fig. 15.—An apple showing pink mold following apple scab and causing the decay of the fruit. (Original.)

Fig. 16.—The pink mold fungus highly magnified, a, mycelium giving rise to spore stalks each bearing a cluster of spores at its apex; b, spores more highly magnified. (Original.)

This mold has been recently noted by Eustace as causing great destruction of packed apples in New York. It has also proven a very serious cause of decay in this state during the past season. Greenings seem to be especially liable to its attacks although it has appeared abundantly on some other varieties. This fungus attacks the fruit in the wounds caused by apple scab, causing at first a brown discolored area around the scab. Soon the spot becomes partly covered with a pinkish moldy outgrowth of spore producing threads. The outbreaks of this fungus have been associated with two successive seasons of cool moist weather and may ordinarily not prove so destructive during years when such conditions are less prevalent. However, it may be expected to appear on badly scabbed fruit.

PREVENTION AND TREATMENT.

The manner in which the fungi causing soft rot enter their hosts, namely through wounds or ruptures in the skin of the fruit, emphasize the need of keeping this protective covering as whole and sound as possible. Thus spraying with fungicides to reduce scab and with insecticides to keep off insect enemies which bite or bore into the fruit will greatly lessen the attacks by the soft rot fungi. Care in handling so as not to bruise or break the skin of fruit is also necessary to prevent loss from these sources. Cold storage, keeping the temperature below 45 degrees F. is also a valuable means of keeping fruit. Experiments in the dipping of apples in solutions of formalin, and exposing them to sulphur fumes have thus far failed to prevent the rotting of fruit thus treated. Similar experiments by others with copper sulphate solution and formalin have also shown that while some rots like the pink mold may be reduced, the blue mold is apparently not checked by such treatment. Frequent sorting of fruit in storage, removing all decaying specimens, also tends to decrease the loss from this cause.

DISEASES OF THE PEACH.

PEACH YELLOWS.

Fig. 17.—Peach Yellows. A, B., fruit from yellows affected tree, showing surface and flesh spotted and streaked with red; C, a prematurely ripened fruit on affected branch which is attached to one bearing healthy foliage and fruit. a, stub of tree budded with bud from yellows affected tree and showing the characteristic growth due to the disease, which has also affected the lower branch b: a, affected tree showing forced dormant buds which are giving rise to bunches of wiry twigs and narrow leaves; b, one of these clusters enlarged; c, a healthy leaf by the side of a branch bearing diseased foliage, showing the contrast in size. (A, B, a, b, after Erwin Smith, the others original.)

Although the disease known as Peach Yellows has been known in this country for more than one hundred years the real cause of the malady is still unknown. Like consumption in the human race "yellows" is one of the most dreaded of the diseases to which the peach is subject for when once this insidious foe appears in a tree certain death is the result.

In bearing trees the premature ripening of the fruit is one of the first indications of the presence of yellows. This may occur from one to six weeks earlier than the normal period of maturing. Such fruits are also highly colored possessing red spots and streaks which often extend from the surface to the pit, the flesh being marbled and streaked with red. The buds formed during the summer, for growth the next season are also sometimes prematurely unfolded. But the most characteristic feature is the growth of bunches of slender twiggy branches during summer and autumn from the crotches and upon the older branches. These wiry shoots bear narrow sickly leaves of a yellow color and being produced in clusters give a characteristic appearance to affected trees.

Trees which show these characters—premature ripening of fruit; fruit spotted and blotched with red; twiggy, clustered shoots bearing small yellow foliage may be considered as unmistakably affected with yellows and should be at once condemned to the fire heap. Although the exact manner in which peach yellows is naturally spread from diseased trees is not understood, it is known to be contagious. Thus its appearance in one part of an orchard is almost certain to be followed by other cases unless the first trees to show it are removed without delay. Artificial infections may arise when buds from yellows-affected trees are used in budding, hence this means of dissemination should be guarded against by the use of buds from stock of unquestioned health. The spread of the disease by the use of pits from yellows affected fruit is believed to be small as such pits are not liable to germinate.

Control of Yellows.—Thus far the only successful measures employed in combating the disease have been of a preventive nature. This consists of digging or pulling out and burning every tree which shows the characteristic symptoms of yellows and the more promptly this is done the better for the health of surrounding trees. Fertilizer tests with a view to lessening or preventing the spread of the disease have not been successful and the same may be said in regard to the matter of spraying.

Peach Rosette is a disease of the peach in the southern states. Its effects on the tree are similar to those of yellows and like that disease it is to be controlled only by destruction of affected trees.

LEAF CURL.

(Exoascus deformans.) (Burk.) Fckl.)

This disease affects the leaves of the peach causing great distortion. The leaf becomes thickened, bent and twisted sometimes only in part or the entire blade may be affected, the fungus causing a blistered appearance very characteristic of the disease. A similar appearance is sometimes caused on leaves of peach, plum and cherry by the attacks of plant lice, but in this case the presence of the lice will usually indicate the true cause of the curling of the leaves. The trouble appears soon after the foliage is expanded causing the affected leaves to fall off. In severe cases, the trees may be entirely stripped of their foliage and normal growth seriously checked. Bearing trees lose their fruit for the season and often fail to form fruit buds for the next. A new crop of leaves generally appears after the falling of the first but the check is often so severe as to prevent the proper maturing of the new wood in time to resist freezing.

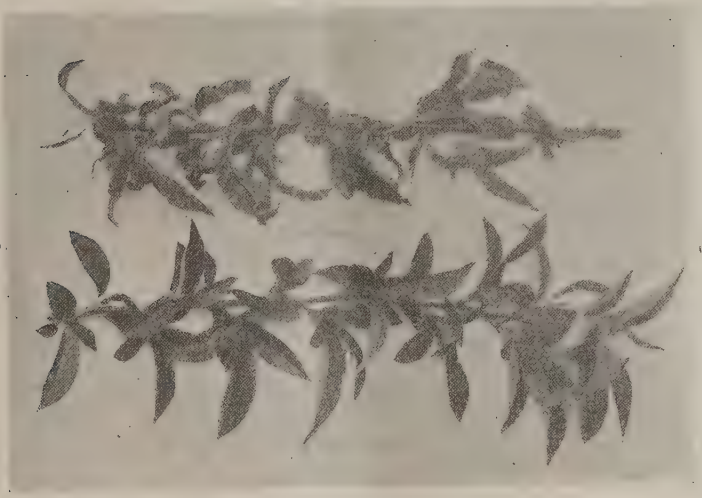

Fig. 18.—Peach leaf curl showing healthy and diseased foliage. (Taft.)

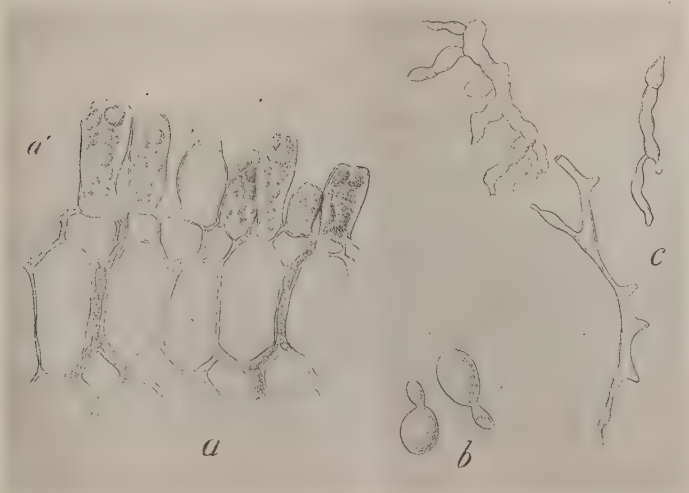

Fig. 19.—Microscopic structure of leaf-curl fungus. a, portion of section through affected leaf showing the spore sacs (asci). a, seated on cells of the leaf; b, two spores budding like yeast cells; c, fragments of mycelial threads from tissue of affected leaf, all highly magnified. (Original.)

The fungous parasite lives through the winter in the form of mycelium in the buds and twigs of affected branches and grows out with the new leaves in the spring. It has been demonstrated, however, by recent investigations that most of the early infections of the foliage arise not from this hybernating mycelium but evidently from spores produced during the previous season. Thus it has been found possible even by a single spraying to reduce the number of infections 90%—98% which would not be the case if they arose from a perennial mycelium. The spores are produced in minute cells which cover the surface of the deformed leaves. The conditions which appear to favor the infection of healthy foliage are a low temperature with abundant rainfall during the early part of the growing season.

Treatment.—The fact that the mycelium of the fungus hibernates in the living buds of the tree would seem to point to the uncertainty attending any efforts to check the disease by spraying. But while spraying may not affect the disease already present in the tree it is very useful in preventing its spread to healthy leaves and the consequent establishment of the fungus in the newly forming buds. Hence in this case the use of fungicides is apt to show most benefit during the season following the applications. The work of Prof. Taft in Michigan shows that very beneficial results may be expected from the use of one thorough spraying with copper sulphate solution two or three weeks before the buds open. This treatment if given before April 1 should entirely prevent the disease.

BROWN ROT.

(Sclerotinia fructigena (Kze. & Schm.) Norton.) (See Plum.)

CROWN GALL.

(Dendrophagus globosus Toumey.)

The disease known as crown gall has been noticed in Michigan only during the past six or seven years but it is already recognized as a serious foe to the culture of the peach. As its name indicates, trees affected with this disease show galls or knots of soft, corky or spongy tissue located most frequently at the crown of the root system although they also occur on the roots and sometimes on the stem above ground. These knots when young have the same color as the roots but as they become older the surface darkens becoming rough and warty. They may vary in size from that of a hazelnut to bunches as large as one's fist. These galls usually begin to decay toward the end of the season and fall away, being followed by new galls on other portions of the roots. Thus a new crop of the galls is produced with each season. The effect of this disease on the trees is such as to produce a spindling or stunted, sickly growth, and usually leads to the death of the tree. Trees affected with crown gall when planted from the nursery seldom reach bearing size but frequently die the first season.

While many causes have been assigned for the formation of the galls characteristic of this disease the true one has been found to exist in the presence of an organism belonging to the myxomycetes, or slime molds. This matter has been determined by Toumey in Arizona who used almond seedlings infected with the disease for investigation. In its early stages

the parasite consists of colorless microscopic masses of protoplasm which inhabit the cells of the knot. Under certain conditions these protoplasmic masses unite and come to the surface of the galls where small rounded spore-producing bodies are formed. The disease is spread most rapidly by means of infested nursery stock. There is evidence also that the disease may spread through the soil for limited distances and its contagious nature is clearly established.

Treatment.—The nature of this disease gives small hope in the matter of a cure, hence prevention is the chief source of relief. Some benefit has been derived from the removal of the knots which form at the crown of the roots and painting the wounds with a paste composed of copper sulphate and lime. Other galls will form on the roots further underground but are not considered of as much importance as those which occur on the crown. In most cases, however, it will be better to dig out and burn affected trees. Careful inspection of nursery stock should be made before planting and all affected trees rejected and burned. Crown gall is also believed to be communicated to the peach from the raspberry and blackberry but especially from the former. Hence the planting of raspberries between the peach rows is to be avoided as galls are quite commonly found on the former.

SCAB.

(Cladosporium carpophilum Thom.)

The disease known as peach scab, or merely "scab," causes dark colored velvety spots which are frequently most numerous on one side of the fruit. When the spots are very numerous they run together and in bad cases cause the fruit to harden and crack open. In such instances too the fruit often fails to develop evenly but is one sided. The disease is especially common on certain kinds, some seedling varieties seeming to

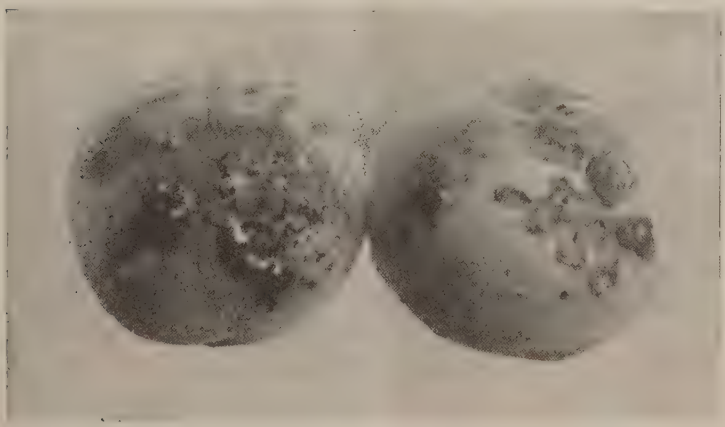

Fig. 20.—Peaches affected with the scab fungus, showing gum oozing from cracks in the fruit. (Original.)

be especially susceptible to its attacks. While the peach scab, like that of the apple, is confined to the surface of the fruit its effects may be such as to render the crop almost worthless and even in moderate cases the market value of the fruit is apt to be materially reduced. This fungus also sometimes causes spotting and shothole effects on the foliage. The disease is most prevalent during rainy seasons. It also attacks the plum and cherry.

Treatment.—While scab is a surface parasite it is not as readily controlled by fungicides as might be expected from that fact. Nevertheless persistent spraying with Bordeaux mixture has been found to materially reduce the amount of scab.

LITTLE PEACH.

Within the past few years a serious disease of the peach which has come to be known as "Little Peach" has appeared in the western fruit belt of Michigan. Dr. Erwin F. Smith of the Department of Agriculture, Washington, D. C., who has made extensive investigations of the peach yellows disease has also studied the little peach and from a paper by him on this subject the symptoms which characterize the disease have been taken. 1. The Little Peach, as its name implies, produces a dwarfing of the fruit. 2. The fruit is retarded in ripening. 3. There is no red spotting of skin or flesh. 4. The leaves are dwarfed and yellow from the beginning. 5. The winter buds do not sprout in Peach Yellows. In most cases these symptoms differ decidedly from those of yellows with which this trouble is apt to be associated by persons not familiar with that disease.

So far no definite cause leading to this disease has been discovered, although the subject has been carefully studied during the past season. So far as noted, the trouble is not confined to trees of any particular age, variety, or location as to soils, although the majority of attacks seem to occur on trees over five years of age and on the heaviest bearers such as Chili, Gold Drops and Smock.

While no specific organism of a parasitic nature has been assigned as the true cause of little peach the trouble is apparently one originating in the underground portions of the tree, thus leading to the reduction or cutting off of the water supply. Thus far the only method which seems capable of holding this disease in check is the prompt removal and destruction of the affected trees. This is the treatment which is being followed by the most extensive growers of the peach and the same that has been successfully employed in checking the extension of the yellows.

Other fungous diseases of the peach of less importance to Michigan peach growers.—

RUST.

(Puccinia pruni-spinosae Pers.)

The rust which attacks the leaves of the peach in some portions of the country also affects the leaves of the cherry and plum. This fungus is closely related to the rust of grain (*Puccinia graminis*) and causes rust-like spots on the lower surface of the leaves which are induced to fall off prematurely. This disease is troublesome in the southernmost states.

PEACH MILDEW.

(Sphaerotheca pannosa Lev. & Podosphaera oxyacanthae (D. C.) D. By.)

Mildew attacks leaves and twigs and later the fruit also, covering the former with a whitish coating and on the latter producing spots of a light color, hardening of the flesh and an abnormal development of hairs or fuzz. Only those varieties which have serrate margined leaves and do not possess glands on the leaves seem to be affected. It is readily controlled by copper sulphate solution and Bordeaux mixture.

BROWN OR PUSTULAR SPOT.

(Helminthosporium carpophilum Lev.)

This disease was first noticed in Michigan in 1893 as being most common on the Wager variety. Affected fruit shows small, rusty spots which gradually increase in size after the fruit begins to ripen. The disease is confined to the surface of the fruit hence is readily controlled by spraying with fungicides.

CONSTRICTION DISEASE OF STEM AND BRANCH.

(Phoma persicae Sacc.)

A disease which causes a groove-like constriction of the stems and branches of peach trees due to a fungus parasite has been described as occurring on nursery stock and on young shoots of older trees in Ohio. The portions of the stem or branch above the constriction die back. Cutting off the affected parts below the constriction is recommended, the removed portions to be burned.

SHOT HOLE FUNGUS.

(Cylindrosporium padi Karst) (See Plum).

LEAF SPOT FUNGI.

Several fungi of a more or less parasitic nature have been noticed as occurring on peach leaves, being associated with spotting of the foliage. Among these are *Macrosporium commune Rabh.*, recorded as frequent in Ohio, and *Cercosporella persica Sacc.* The latter fungus produces a frosty growth on the under surface of the spots. It is more common in the south than here. Neither of these fungi is to be regarded as serious in its effects.

Cercospora circumscissa Sacc. also causes spotting of the leaves of the leaves of peach, cherry, almond and apricot, the pieces of dead tissue falling out later thus giving rise to a shot-hole effect.

PLUM DISEASES.

BLACK KNOT.

(Plowrightia morbosa (Schw.) Sacc.)

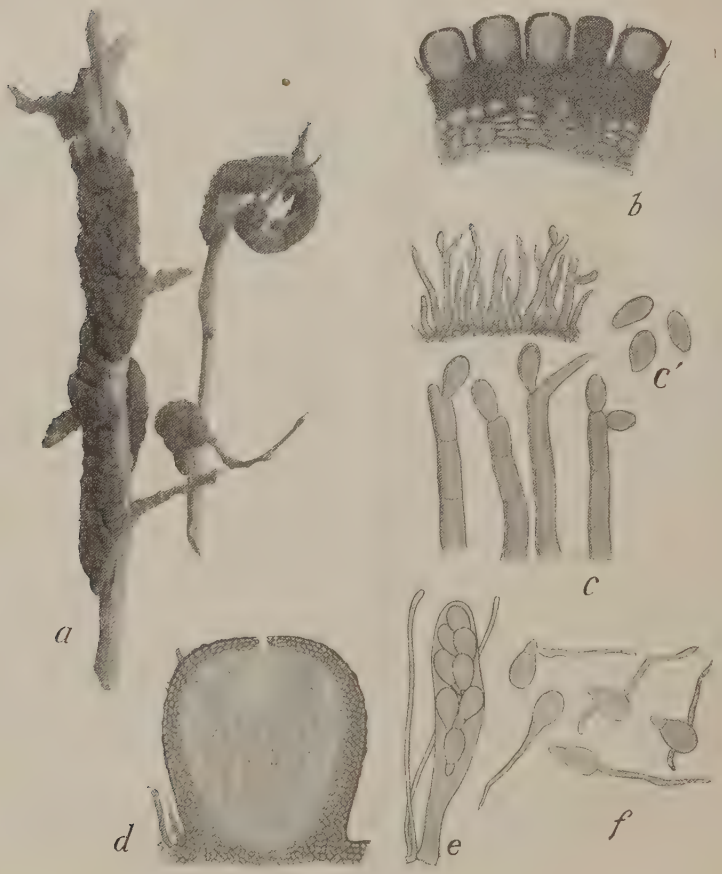

Fig. 21.—Black Knot fungus. a, mature knots on plum branches; b, magnified section of a knot showing the spore cases (perithecia); c, spore stalks (conidiophores) which grow on the surface of the knots when young and give rise to summer spores (conidia), c: d, section of a winter spore case (perithecium) more highly magnified, showing numerous contained spore sacs (asci), one of which is shown very highly magnified at e: f, several of the two celled winter spores germinating in water. (Original.)

Black knot of the plum and cherry is one of those destructive fungous diseases the effects of which are quite liable to be mistaken for the attacks of some insect parasite. In fact, for a long time it was believed even by scientists that the peculiar black, knotty growths which often appear on these trees were due to this cause. It is definitely known, however, that these knots are the direct result of the presence of the mycelium of a fungus parasite in the tissue of the branches and that insect larvæ when found are merely feeding on the swollen tissues. The first evidence of the presence of this disease is the formation of irregular, knotty swellings on the young growth, the knots often extending along the branch more on one side than on the other, in such cases the branches being frequently much curved or distorted. At first these knots possess a dark olive color and a velvety surface. This appearance is due to the great number of minute spore-bearing stalks which grow on the surface of the knot. The spores shed from the velvety knots are capable of infecting other branches during the present growing season so that the knot becomes a source of contagion even in its early stages. Late in the winter the knot has lost its velvety appearance leaving a dead black, uneven, more or less cracked surface. Under a hand lens the outside appears to consist of small, closely crowded pimples or pustules with a minute depression in the center of each. A section through one of the knots, when examined under the compound microscope, shows these pustules as hollow, thick-walled bodies lined with a layer of club-shaped cells (asci) containing spores. These are the winter spores and serve to start the fungus anew the next season. Hence the knots if left on the trees over winter also serve once more as centers of infection. Furthermore, the mycelium which has caused the knot is capable of spreading into any new shoots which may arise near it. Sometimes trees become so badly infested with this disease as to present a mass of knotted limbs which have just enough vitality to push out a few leaves and make a feeble growth, while many of the branches die each season.

Treatment.—As the knots form early in the growing season they should be removed at once and not left to produce spores. The branch bearing the knot should be cut several inches below the swelling to remove all mycelium. Burn the knots as soon as removed. While the thorough removal of the knots will usually serve to keep this disease in check it may be advisable to spray with some fungicide especially if there are wild cherry trees or other plum trees in the neighborhood on which the disease is allowed to exist.

BROWN ROT.

(Sclerotinia fructigena (Kze. & Schm.) Norton.)

This fungus undoubtedly destroys more plums than any other one disease. It is also very destructive to peaches, especially the early varieties which frequently rot badly on the tree and in transportation and storage. The cherry too, is subject to this disease which often attacks the blossoms, leaves and young shoots as well as the fruit. It is also not uncommonly found on apples, especially early varieties, and has been induced to grow on raspberries, blackberries and numerous other fruits. In fact this is one of those fungus pests which seem capable of adapting itself to almost any of the horticultural fruits although it is especially common on the

stone fruits. Among plums, the Japanese and American varieties seem less subject to the brown rot than the European or "Domestica" type. Of the latter the Lombard is especially subject to this disease.

The disease manifests itself on the fruit by the formation of a rapidly enlarging, brown discoloration, hence the name brown rot. Sometimes only a few hours are needed for this fungus to cause the decay of affected

Fig. 22.—Plums affected with brown rot found on trees in February, showing mummified condition. These plums still retain the ability to give off spores (conidia).

specimens. Plums which have been bitten by the plum curculio and the plum gouger are almost sure to decay by means of the brown rot, the spores of which are enabled to infect the fruit in these wounds. After the disease is well established the epidermis of the fruit becomes ruptured in many places by the spore-bearing branches of the mycelium which push out in little tufts. These ash-colored tufts have a powdery appearance due to the great number of spores (conidia) given off. When several

plums are in contact with an affected one they are all pretty sure to rot and instead of falling off remain on the trees nearly all winter. One of the most common sights in the average plum orchard during winter is furnished by these mummy fruits which were attacked by the brown rot during the previous summer. In spring these diseased plums become softened by rain and the dormant mycelium which they contain may give rise to another crop of spores (conidia). Another spore-form has been recently discovered. Thus when the mummified fruits have lain partly covered with soil on the ground they may give rise in spring to little

Fig. 23.—a, Section through a diseased plum showing a spore pustule bursting through the skin of fruit and producing chains of spores (conidia); b, part of a spore-chain; c, spores germinating in a drop of water, (all highly magnified): d, an old mummy plum which has lain on the ground over winter giving rise to small fleshy outgrowths (ascophores in form like little wine glasses; e, one of these outgrowths somewhat enlarged; f, some of the slender spore sacs (asci) which line the cup like part of the fleshy organs shown at d, e; g, mature spores from a spore sac, highly magnified. (Original.)

fleshy outgrowths somewhat resembling wine glasses with long stems. The cup-shaped part of these outgrowths is lined with a spore-bearing layer in which are minute spore sacks (asci) each containing eight spores. When mature these spores are discharged and may infect the new crop of fruit. The brown rot fungus sometimes attacks the tender foliage and young shoots causing them to turn brown. When the fungus gains an entrance into wounds on branches it may cause a kind of canker from which a flow of gum is the result. The writer has frequently seen "gumming" of the shoots of the flowering almond with consequent death of the upper portion due to this fungus.

Treatment.—A fungus which can thrive on so many hosts is not easily prevented from occurring in the orchard. The fact however, that the mummified fruits serve to carry this fungus through the winter should indicate the need of gathering and burning them instead of leaving them, as is

usually the case, to serve as centers of infection. Thorough spraying with Bordeaux mixture and other fungicides, while reducing the amount of the brown rot, seldom succeeds in entirely preventing it. It has been found that where insecticides are used, thereby reducing the attacks of the curculio that the brown rot is less severe. This is also the case when the trees are jarred for the same purpose. This process serves not only to remove the curculio to quite an extent but also causes most of the rotting plums to fall off, thus removing one cause of the spread of the fungus. Thinning the fruit will aid in controlling this disease. The trees should be thoroughly sprayed before the buds open, with poisoned Bordeaux or a solution of copper sulphate, one pound to twenty-five gallons of water, then again with Bordeaux just before blooming, and again just after blooming to be followed by another spraying when fruit is three-quarters grown. Ammonia-copper carbonate solution should be used when the fruit begins to color.

PLUM POCKETS.

(Exoascus pruni Fckl.)

The disease known as plum pockets or bladder plums is due to a fungus parasite which is closely related to that of the leaf curl disease of the peach. Like that disease it possesses a hybernating mycelium which lives in the tissues of the twigs and young branches. When growth begins in spring this mycelium grows out into the young ovary of the blossoms. Soon after the petals fall the young fruits become swollen and often lengthened or distorted. When cut open they are found to be hollow and without a pit as the stone fails to develop. These bag-like fruits are at first yellowish tinged with dingy red and later appear to be covered with a whitish bloom. This appearance is due to the numerous minute spore-sacks (asci) which cover the surface of the diseased plums. After the spores are discharged from these spore sacks the plums turn dark and fall off.

Treatment.—Trees which are once affected with this fungus continue to bear bladder plums year after year. Cutting off those branches which show the disease, as soon as noticed, will tend to prevent its further spread. However, when a tree is thoroughly infected so that all the fruit is diseased it may better be dug out and burned. Plum trees which are sprayed each season are not liable to be infected with this fungus.

SHOT-HOLE FUNGUS.

(Cylindrosporium padi Karst.)

Several fungous diseases are known to produce shot-hole effects on the leaves of plants. The above named fungus, however, is most commonly associated with that trouble on the foliage of plum and cherry. Affected leaves become disfigured with numerous small spots of dead tissue which soon separates from the healthy portion and drops out leaving perforations suggestive of the name shot-hole disease. The spores are produced in minute pustules in these dead pieces of leaf tissue. When severe, the leaves fall off prematurely thus causing a serious check to the maturing of fruit and wood.

Treatment.—Where this disease is prevalent about two or three sprayings of Bordeaux mixture will be needed to prevent it, although a single application may prove very beneficial. The first application should be made when the leaves are well out and before they are inoculated by the spores of the disease. The other applications, if needed, may be used at intervals of two or three weeks.

Fig. 24.—Leaf of plum affected with the shot-hole fungus.

GUMMOSIS OR GUMMING OF STONE FRUITS.

The flow of gum from branches of plum, peach, cherry, almond, etc., has in some cases been attributed to the presence in the tissues of a parasitic fungus. Thus Massee describes a gummosis of the flowering almond due to the attacks of *Cladosporium epiphyllum* and a similar trouble on the same plant has been noted by the writer under the head of Brown Rot of Plum (*Sclerotinia fructigena*).

Cladosporium epiphyllum has also been found causing gummosis on the purple-leaved variety of the Myrobalan plum grown for ornament at the Agricultural College while the same disease on cultivated plums has been found to be associated with a species of Cladosporium. In many cases

the trouble probably begins in some crack or wound which allows the fungous parasite to gain an entrance. The presence of the mycelium induces a flow of sap which exudes and hardens forming tear-like drops, sometimes of considerable size. This gum is partly utilized by the fungus in the production of more spores. The portion of branch beyond the affected spot may in some cases be killed or permanently weakened. In such cases the branch should be cut off below the diseased area and burned. The use of fungicides will serve to reduce the tendency toward gumming.

Boring insects of the peach, plum and cherry may also cause a flow of gum from the wound made in entering and these wounds probably often serve to allow the entrance of fungi. hence the desirability of combating the insect enemies of these trees.

DISEASES OF THE CHERRY.

POWDERY MILDEW.

(Podosphaera oxyacanthae (D. C.) De By.)

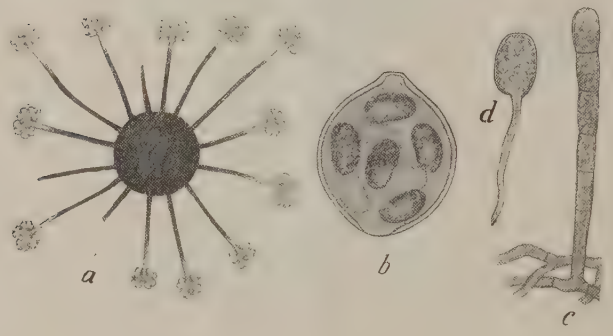

Fig. 25.—Powdery mildew of the cherry, etc. a, A winter spore case (perithecium) magnified, showing the appendages with peculiarly branched tips; b, the one large spore sac (ascus), containing eight spores, which is contanied in the spore case, a: c, the summer spore form of the fungus showing the formation of spores (conidia) by the dividing of a spore stalk (conidiophore): d, a spore germinating in water. (Magnified, original.)

The powdery mildew is a superficial fungus, that is, it spreads over the surface of the host plant merely sending short sucker-like growths (haustoria) into the epidermal cells. These serve alike the purposes of holdfasts and feeding organs for the parasite. This disease appears on the foliage producing a white, moldy appearance due to the numerous mycelial threads which form a delicate felt-like layer. From these threads arise minute, erect stalks which divide into a number of cells each of

which becomes an egg-shaped spore. The great number of these spores forming on the surface of the leaf gives a powdery appearance suggestive of the common name. These are the summer spores. They germinate as soon as they fall into a drop of moisture and if in contact with a young cherry leaf set up the disease. Later in the season dark brown specks appear among the matted threads of mycellum, each armed with a number of thread-like appendages furnished with peculiarly branched ends. These dark bodies are the resting spore cases which remain dormant through the winter and give off several spores in the spring to start the disease anew.

The powdery mildew, while not often serious on large trees, may cause much damage to the leaves and tender shoots of seedling cherries in the nursery. The same disease is common also on the foliage of the plum, young apples and hawthorn.

Treatment.—Trees which are treated for shot-hole and brown rot with Bordeaux mixture will need no further treatment for this disease. For seedling trees the sulphide of potassium solution or the ammonium copper carbonate mixture may be used.

RUST.

(Puccinia pruni-spinosae Pers.) (See on Peach.)

SCAB.

(Cladosporium carpophilum Thum.). (See Peach Scab.)

The cherry is subject to a number of diseases common to the plum. Among these the following are described under that head,—

Black Knot (*Plowrightia morbosa* (Schw.) Sacc.).

Brown Rot, Fruit Mold (*Sclerotinia fructigena* (Kze. & Schm.) Norton).

Shot-hole Fungus, Leaf Spot (*Cylindrosporium Padi Karst*).

DISEASES OF THE GRAPE.

BLACK ROT OF THE GRAPE.

(Guignardia Bidwellii (Ell.) V. & R.)

Fig. 26.—A bunch of grapes many of which have rotted with the black rot fungus. (Original.)

Among the numerous fungous diseases to which the grape is subject no other is so destructive to the fruit in this country as the one known as black rot. Thus the labor and fruit of a season may be swept away in a few days when the conditions are favorable. In some places grape growing, once a profitable industry, has been almost entirely abandoned on account of the ravages of this fungous parasite.

The disease attacks all parts of the vine except the roots. The leaves and young shoots first show its effects by the appearance of brownish spots of dead tissue. The fruit is often attacked when only half grown although the greatest destruction usually follows a warm, moist period of weather a little before ripening. Affected berries first show brown or dark colored spots which rapidly enlarge until the whole berry is in-

Fig. 27.—A, Concord grapes diseased with black rot and found hanging on vines in March; b, small portion of surface, magnified, of diseased grapes showing pimples or pustules; c, section of a pustule showing formation of numerous minute spore-like bodies (spermatia); d, section of another pustule which produces the summer spores which are seen oozing out of the protruding mouth; e, separate spores; f, a spore sac (ascus), containing eight winter spores which are produced in a pustule similar to d, on the diseased grapes which lie on the ground over winter. (d, e, f, after Scribner, in part; the others original.)

volved. Wrinkling of the fruit due to drying, then takes place, the affected berries remaining attached to the stems. Such fruits possess a black, strongly wrinkled surface studded with minute points or pustules which lie just under the skin. These little pustules are spore-forming organs and have a small projecting mouth through which the spores are discharged when the grape is wet. On becoming dry these microscopic

spores may be carried to other parts of the plant or vineyard thus serving to disseminate the disease during the growing season. Other spores produced in another manner also serve the same purpose.

The old grapes and diseased leaves, moreover, when left on the vines or lying on the ground give rise to another spore form, the spores being produced in spore sacks (asci) contained in little cavities (perithecia). This spore form remains dormant until spring thus carrying the disease through the winter.

Treatment.—The fact that the old diseased leaves and grapes are the hibernating places of this fungus points out the need of destroying them before growth begins in spring else the disease is almost sure to reappear. Raking and burning all trimmings and burning all diseased fruit as fast as it appears has served in some cases to hold this disease in check. Spraying with Bordeaux at the first appearance of the disease if thorough and persistently followed will in most cases serve to control the black rot. One spraying with copper sulphate solution before growth begins should be made, and after leaves are out Bordeaux mixture should be applied at intervals of two or three weeks until grapes are about half grown. After this some clear fungicide may be used, such as weak copper sulphate solution, ammoniacal copper carbonate or soda Bordeaux which will not stain the fruit. Sprayings, in many cases, will not need to be continued after August first.

DOWNY MILDEW.

(Plasmopara viticola B. & C.)

As a destructive disease of the grape the downy mildew probably holds the highest rank. It affects all tender growing parts of the vine. On the leaves it first produces pale spots on the upper surface. These spots soon become brownish while on the lower side of the leaf a whitish downy outgrowth appears suggestive of the common name. This appearance is due to the formation of immense numbers of spore bearing branches which grow out in tufts through the stomata in the lower epidermis. Each branch produces many egg-shaped spores (conidia) which may germinate at once if moisture is present. In germinating each conidium gives rise to several minute protoplasmic bodies (zoospores) capable of swimming about in a drop of water for a short time but soon coming to rest. They now send out a germ tube which may enter the host plant thus causing infection. Young shoots are also affected being soon killed by the rapidly spreading mycelium which passes between the cells, into which short sucker-like projections (haustoria) are sent. In this way the vines may be much weakened. The berries are usually affected when only partly grown. On these the fungus produces brownish spots which rapidly enlarge soon involving the whole fruit, which may also be covered with downy patches of the fungus. The brown color assumed by the fruit, when attacked, has also given the name brown rot to this disease.

Within the diseased tissues another form of spore is produced which serves as a resting or winter spore. These are larger than the summer spores, possess a heavy, dark colored outer coat, and hibernate in the tissues of the affected parts which may be left in the vineyard. The

downy mildew thrives best during moist weather. It usually appears somewhat later in the season than the black rot disease.

Treatment.—When the black rot and downy mildew occur together, as is quite common, no other treatment will be required than for the former. For the mildew alone, sprayings with the ammoniacal copper solution have been found efficacious. The standard Bordeaux mixture or the soda Bordeaux may be substituted.

Fig. 28.—Leaves and young growth of grape attacked by the downy mildew. The upper surface of the leaves shows brownish spots while the lower side gives rise to a whitish, downy growth.

Fig. 29.—A bunch of grapes attacked by the downy mildew.

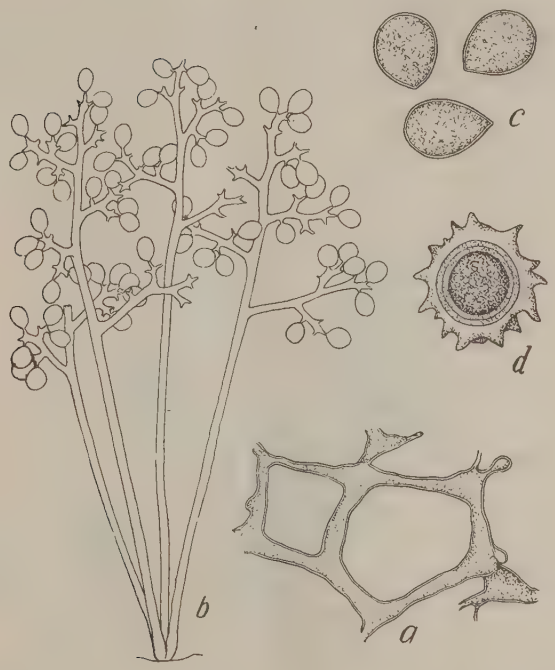

Fig. 30.—Microscopic structure of the downy mildew fungus. A, small portion of the mycelium from a diseased grape: b, a tuft of spore stalks, (conidiophores) which give the downy appearance to affected parts of the host plant; c, mature spores, (conidia) produced during summer; d, thick walled, dark colored resting spore from diseased tissue of grape, highly magnified; (d, after Viala; others original.)

POWDERY MILDEW.

(Uncinula spiralis B. & C.)

The powdery mildew is not apt to prove very troublesome to vineyardists in this state except in graperies and upon European hybrids which are more subject to it than those of native origin. This disease is confined to the surface of the host plant merely sending short suckers (haustoria) into the epidermal cells. It may attack any of the new growth but is most noticeable on the upper surface of the leaves which appear covered with a white moldy growth possessing a powdery appearance. This is due to the great number of spores (conidia) which are produced from upright branches of the mycelium. These are shed in abundance during summer thus serving to spread the disease during the growing period. Later the affected parts show, under a hand lens, minute black bodies scattered about where the mycelium was most abundant. These are the winter spore-cases (perithecia). In spring they burst open thus allowing the escape of the enclosed spore sacks (asci).

Treatment.—Where treatment for no other fungous diseases is required sulphur in the powdered form is usually used. This may be dusted on the vines when dew is on. A solution of sulphide of potassium, one ounce to two gallons of water, may also be used as a spray. The ammoniacal copper solution is also recommended where the disease is of yearly occurrence.

Fig. 31.—Microscopic structure of the powdery mildew fungus. A, a winter or resting spore case, (perithecium), bursting open to discharge the contained spore sacs, (asci): b, a spore sac, (ascus), showing contained spores: c, mycelium from surface of leaf giving rise to spore stalks, (conidiophores), which break up into spores thus producing the powdery appearance of affected parts: d, one of the spore stalks highly magnified, showing how the spores, (conidia) are formed: e, mature summer spore (conidium). (Original.)

ANTHRACNOSE, BIRD'S EYE ROT.

(Sphaceloma ampelinum De By.)

The disease known by the above names does not seem to have proven as serious a trouble to the grape growers of Michigan as of some other states. However, it has been noted from various localities and should be watched for each season by those who grow this fruit to any considerable extent. It affects all the young growing parts of the vines but is apt to be more noticeable when seen on the fruit. The affected berries show, at first, brown spots which are surrounded by a clearly defined margin. The center of the spots later becomes whitish in color while the slightly raised margin assumes a deep brown or purplish hue. Sometimes there is an inner circle of a red color which helps to accentuate the light center of the spots and gives to them the appearance suggestive of a bird's eye. If several spots appear on a berry it soon shrivels up, sometimes, however, only one side may be affected while the other develops thus leading to a one sided fruit which sometimes cracks open exposing the seeds. The

diseased spots are dry and do not extend deeply into the fruit but somewhat resemble the spots of apple scab in their nature.

The spores are produced on the surface of the central portions of the diseased spots. They may be disseminated by rain or currents of air and when lodged on healthy berries in a drop of water soon give rise to the spots characteristic of the disease. While it is not definitely known as to how the fungus passes the winter it is possible that the diseased portions of plants may be the means by which this is effected.

Fig. 32.—Grapes affected with anthracnose.

Treatment.—Removal and burning of affected portions of the vine are to be accompanied by spraying with some of the standard fungicides as for black rot. Treating the vines during the winter with a solution of sulphate of iron to which has been added a portion of sulphuric acid, is also recommended.

RIPE ROT.

(Glomerella rufomaculans) (See on Apple.)
Grape diseases of uncommon occurrence in Michigan.

Bitter rot (*Melanconium fuligineum* (Scrib. & Vial.) Car.) has been noted as occurring in some of the eastern states. It resembles in appearance and effects the ripe rot fungus but imparts a very bitter taste to the diseased fruit.

White rot (*Coniothyrium diplodiella* (Speg.) Sacc.) has been found in Missouri on young shoots and fruit of the grape. The latter assumes somewhat the appearance of that affected with black rot except the color, which does not darken.

Root rot (*Armillaria mellea* (Wallr.) Fr. and *Dematophora necatrix* Hartig.). These two fungi which cause the rotting of the roots of the vine in Europe have also been found, but to a less extent, in this country.

The former is a mushroom of common occurrence in this state in woods and clearings or where there is decaying wood in the soil. So far as the writer is aware it has not been noticed in connection with the rotting of grape roots in this state. The latter fungus is mold-like in its fruiting or spore stage. Both fungi form root-like strands or cords of mycelium but those of the latter fungus are light in color and delicate while those of the mushroom are dark brown or black on the outside. These fungi spread by means of their underground mycelium as well as by spores. Vines which are on poorly drained soil are most apt to suffer from root rot. Good drainage and the prompt removal of diseased plants are recommended as preventatives.

Leaf blight (*Cercospora viticola* (Ces.) Sacc.) causes irregular dark brown spots of dead tissue on the leaves of the grape. It occurs in most of the eastern states but is not usually found to be severe in the more northern portions of this region. It is apparently of little importance to the grape growers of Michigan.

CURRANT DISEASES.

Leaf-spot (Septoria ribis Desm. and Cercospora angulata Wint.).

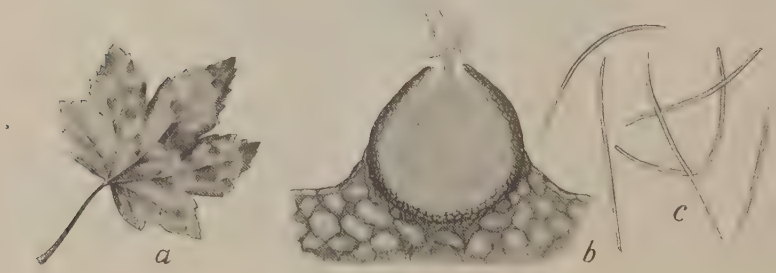

Fig. 33.—a, Leaf of currant affected with the leaf spot disease; b, a spore producing pustule magnified, from a diseased spot of a leaf, giving out long, slender spores a few of which are shown highly magnified at c. (Original.)

The fungi causing leaf-spot of currant and gooseberry are common and destructive to the foliage in this state. Affected leaves at first show small brownish spots during June or July and by August the foliage begins to drop. It is not unusual to see bushes entirely defoliated by this disease long before frosts. Thus the plants are prevented from making a complete growth or of properly perfecting the fruit buds. The spores of these diseases are produced on the dead portions of the diseased leaves on which the fungi also hibernate.

Treatment.—Rake and burn all dead leaves and rubbish in spring. It has been found possible to reduce the attacks of these fungi to a great

extent by the use of fungicides applied at intervals of two or three weeks. during the growing season, the first application to be made early in June. Even two or three applications will materially reduce this trouble. The spray used early in the season, while the fruit is on. should be one of the clear mixtures so as to avoid staining the berries. After harvest Bordeaux mixture may be substituted.

ANTHRACNOSE OF CURRANTS.

(Gloeosporium Ribis (Lib.) Mont. & Desm.)

This disease causes a spotting of the leaves of the cultivated currant but seems less common than the previously mentioned fungi. Its first appearance is made early in summer and like the other leaf-spot fungi causes the leaves to turn yellow and fall off prematurely. The fungus itself produces small brownish spots on the foliage and in the diseased areas the spores are produced. They are one-celled curved bodies of minute size.

Treatment.—If the bushes are treated as for the leaf-spot fungi the anthracnose should not be troublesome.

KNOT.

(Nectria cinnabarina (Tode) Fr. and Pleonectria Berolinensis Sacc.)

A Disease of Currants is the title of Bul. 125 of the Cornell Experiment station. In this bulletin is described a currant disease due to the attacks of two species of fungi which have caused serious trouble in some plantations in New York state. The disease attacks the canes causing the foliage to turn yellow and fall off, eventually leading to the death of the canes. The fruit also ripens prematurely and is of small size.

The fungus appears on the canes in the form of small pinkish cushion-like tubercles usually most abundant near the ground. From these tubercles spores are produced in abundance which are capable of growing at once. Another spore form is produced later in the history of the fungus on the dying or dead canes. It is believed that infection occurs largely through wounds or cuts but after once gaining an entrance the disease becomes deep seated and difficult to eradicate. Spraying is not recommended as being of much service in combating the disease. All diseased plants should be dug out and burned and cuttings made only from bushes in plantations entirely free from the trouble. It would also be advisable to locate new plantations on soil not previously occupied by affected plants.

GOOSEBERRY DISEASES.

GOOSEBERRY RUST.

(Aecidium grossulariae Schum.)

Fig. 34.—a, A young leaf of gooseberry attacked by the cluster cup fungus or rust; b, a young fruit swollen, distorted and yellow in color from the effects of the rust; c, section through part of diseased spot showing a spore-producing cup (aecidium 1, and a spermagonium 2,); d, mature spores (aecidio-spores), two of which are germinating; highly magnified. (Original.)

The gooseberry rust fungus while not very destructive as a rule, is capable of doing considerable damage to foliage and fruit. It also occurs on wild species of currants to some extent. The disease manifests its presence in early summer by causing the formation of swollen places on the leaves and enlargement and distortion of the fruit. These swollen parts are readily recognized by their bright yellow to orange color and the presence of little cup-shaped pits in the surface. These little cups give off spores at maturity as in the case of the apple rust fungus. By some this early rust stage is believed to be connected with a later one represented by *Puccinia ribis D. C.*, which corresponds to a similar spore stage of other rust fungi.

Few suggestions for treating this disease are given. While sprayed plants are less apt to show the disease in its worst form yet it has been found by the writer on plants thus treated. To be at all effectual spraying should be made early, as the fungus when once established in the tissues of its host cannot be reached by external applications. Picking and burning diseased parts has been suggested as likely to reduce the attacks for the succeeding season. The copper sulphate solution should be tried just before the buds open in spring to be followed by one of the clear fungicides after the fruit has formed.

POWDERY MILDEW.

(Sphaerotheca mors-uvae (Schw.) B. & C.)

The powdery mildew of the gooseberry and currant is widely distributed and is capable of causing considerable damage to foliage, young shoots and fruit. It may appear quite early in the season and continue for some time. Affected parts at first appear to be coated with a whitish cobweb-like growth of minute threads. These soon give rise to spore bearing stalks in abundance each minute stalk breaking up into a chain of colorless spores thus giving a powdery appearance to the diseased portions.

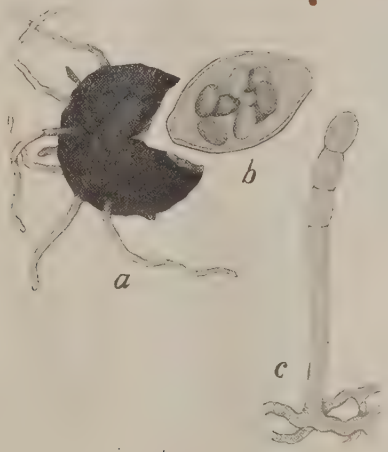

Fig. 35.—Powdery mildew of gooseberry. a, A resting spore case (perithecium), discharging its single spore sac, (ascus) which contains eight winter or resting spores: c, the summer spore stage of the disease, showing a spore stalk, (conidiophore), which divides thus forming spores which soon fall apart; magnified. (Original.)

While the fungus is confined to the surface of the host plant it obtains nourishment by means of minute sucker-like branches (haustoria) which enter the epidermis of affected parts. Later in the season the fungus threads darken in color and if examined with a lens will be found to have small dark bodies imbedded among them. These little specks are the resting or winter spore cases (Perithecia) of the fungus and are destined to carry the disease over to the next season. The gooseberry mildew thrives best in the warmer portions of the United States and during the hottest seasons. It has been found to be especially bad also on the foreign varieties of the gooseberry while the native sorts are less subject to its attacks.

Treatment.—As powdery mildew is an external parasite it yields quite readily to treatment. Spraying should be begun as soon as the leaves are unfolding; the first application may be of Bordeaux mixture but the potassium sulphide solution should be used as soon as the berries are about half grown to avoid staining them.

LEAF-SPOT DISEASE. (See on Currant.)

DISEASES OF RASPBERRY AND BLACKBERRY.

ORANGE RUST OF RASPBERRY AND BLACKBERRY.

(Caeoma luminatum Lk.)

Fig. 36.—a, A small leaf of raspberry showing blisters produced by the orange rust fungus: b, spores from a blister: c, sectional view of pith cells from diseased cane, showing a strand of mycelium m, passing between the cells and giving rise to sucker-like branches (haustoria), h, h, h, which enter the cells and absorb their nourishment. Magnified. (Original.)

The disease of blackcap raspberries and of the blackberry, known as orange rust, is probably the most serious of the fungus diseases of these plants. The fungus possesses a perennial mycelium which lives in the pith of affected canes and even extends into the underground portions of the host plant. In the spring the leaves borne on such canes appear to be covered with small blisters of an orange yellow color which often unite in irregular zigzag lines. These blisters occur on the lower surface of the leaf and soon after their appearance the epidermis of the leaf ruptures along the center of the swellings thus allowing orange colored powdery spores to escape. These spores are capable of germinating as soon as shed and if they fall into a drop of moisture in contact with a healthy leaf of the host plant may produce an infection. After gaining an entrance into the leaf the mycelium finds its way through the leaf stalk into the pith of the cane where it lives until the next season to again grow out into the new foliage. This mycelium does not enter the cells of the host plant but passes among them through the intercellular spaces sending peculiar knotted branches (haustoria) into the cells.

By some botanists the orange rust is considered to be the Aecidial stage of *Puccina Peckiana* Howe, which corresponds to the winter spore stage of the rust. The latter fungus also occurs later on the leaves of the raspberry, especially those which bore the orange rust earlier in the season.

The effects of this parasite are shown in the reduced vigor and size of diseased plants, the new growth being sickly and slender while the entire plant eventually dies. The perennial nature of the fungus enables it to appear year after year when once it gains an entrance into the tissues of the host. Hence plants which are once attacked rarely recover. Any plant, therefore, which shows the characteristic orange colored blisters on its foliage should be dug out and burned at once else it will serve as the breeding place of the parasite. Neither should young plants be taken from among those infested with the fungus as they too will in all probability be affected. Keeping the foliage covered with some fungicide, as Bordeaux mixture early in the season will tend to prevent infection of the healthy plants.

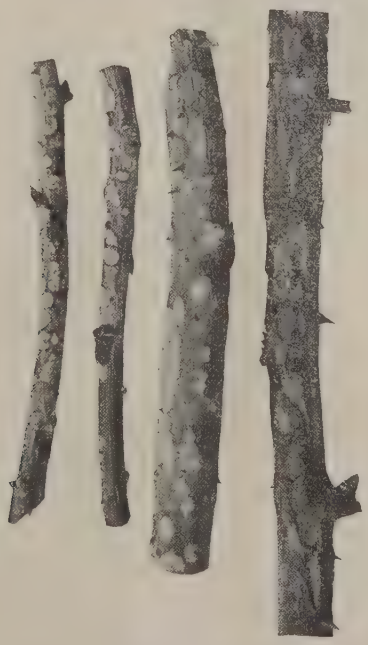

Fig. 37.—Canes of raspberry showing spots produced by the Anthracnose fungus. (Original.)

ANTHRACNOSE OF RASPBERRY AND BLACKBERRY.

(Gloeosporium venetum. Speg.)

The anthracnose of raspberry and blackberry is a common disease of these plants and one which is capable of doing much harm. It affects the canes first, later appearing also on young shoots and leaves. The spots in the early stages of the disease are purple but as the disease progresses

these spots acquire a whitish center and become somewhat sunken. In bad cases the spots run together sometimes encircling the cane; at other times they run along one side producing large patches of a grayish color. During the second season the spots tend to dry out, producing cracks in the wood and scaling of the bark.

On the leaves the spots are apt to be small but numerous and follow the general appearance of those on the canes.

The effect of this parasite is to reduce the vigor and size of all parts of the plant. The fruit often fails to mature properly but frequently dries up before ripening.

Treatment should consist of cutting out the worst diseased canes and spraying. Beginning in spring the first application may be the copper sulphate solution before the leaf buds open. The second, soon after the foliage is out, with Bordeaux mixture. A third spraying with the Bordeaux should follow the harvesting of the crop. Start new plantations from healthy canes or from root cuttings in case of red raspberry and blackberry.

RASPBERRY CANE BLIGHT.

(Coniothyrium sp.)

This is a disease somewhat recently investigated by Stewart and Eustace in the state of New York.

During the past season (1903) the writer found the same disease occurring not only in every plantation examined, but also on wild black raspberry plants in this state. It was especially abundant in an old raspberry patch at the Agricultural College but was found rather rarely in new plantations near the shore of Lake Michigan.

The disease attacks principally the fruiting canes, just before ripening of the fruit, and causes the death of the upper portions of the branch and in severe cases of the entire cane. The first evidence of its presence is shown by the wilting of the fruiting branches above the point affected. These soon dry up with the immature fruit still left hanging. The canes become very brittle at the diseased point while the wood is strongly discolored. The bark at these points is usually lighter colored than surrounding portions and often shows a smutty appearance due to a coating of spores. The spores are formed in minute pustules (Pycnidia) buried in the bark, from which they ooze out on to the surface of the cane. They are one-celled egg-shaped bodies of a dark olive brown color and are believed to be the chief means by which the disease is disseminated.

All varieties of both red and black raspberries are subject to the disease although Cuthbert is mentioned as especially subject to it and Columbian one of the least affected sorts commonly grown.

Treatment.—As yet no successful spraying measures have been found. This is possibly due to the fact that the canes do not hold any liquid substance readily, the bloom causing water to roll off, hence Bordeaux mixture does not readily adhere. Spraying the foliage does no good as the disease affects the canes only. It is recommended, however, that the old canes be cut out and burned as soon as the crop is gathered as well as all canes which show any signs of the disease. New plantations should be started from healthy canes and on soil not recently used for that purpose.

The New York Experiment Station Bulletin No. 226, Geneva, N. Y.

Fig. 38.—Fruiting branch of raspberry attacked by the raspberry cane blight at a. (From photo by H. J. Eustace.)

LEAF-SPOT.

(Septoria rubi Westd.)

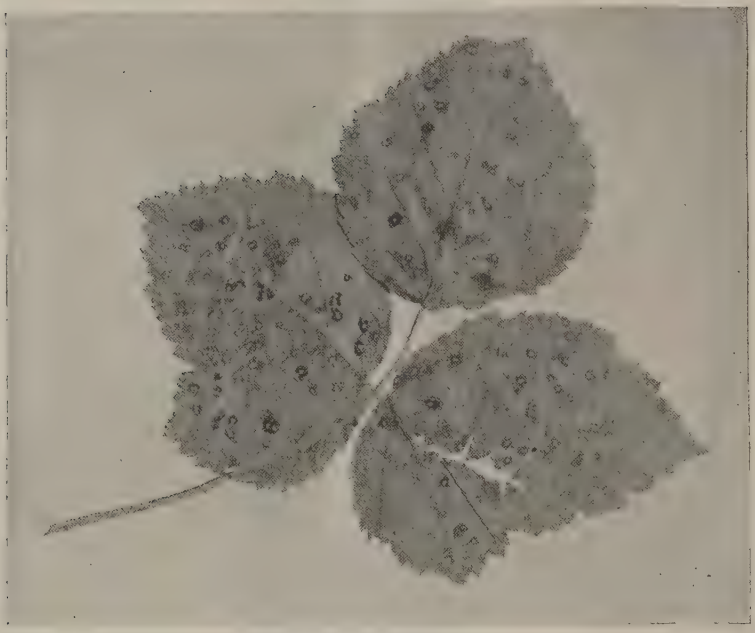

Fig. 39.—Blackberry leaf affected by the leaf spot fungus. (Original.)

A very common affection of the foliage of blackberry, dewberry and raspberry is the spotting due to a minute parasitic fungus called leaf-spot. The disease gives rise to numerous purplish spots which later become lighter in the center in which several small black pimples appear. These little pimples are hollow bodies which give off spores through a minute opening in the apex. The spores are slender curved bodies without color and are scattered by rain and wind.

While the leaf-spot fungus is often abundant it seems to do but little damage especially on plants that are sprayed and cultivated.

STRAWBERRY DISEASES.

LEAF-SPOT DISEASE OF STRAWBERRY.

(Sphaerella fragariae (Tul.) Sacc.)

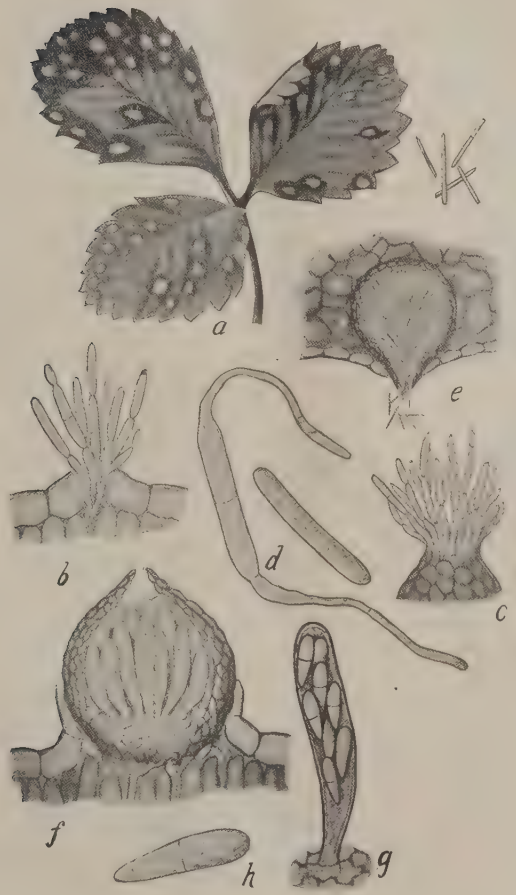

Fig. 40.—a, A leaf of strawberry affected with leaf blight; b, spore bearing tuft of mycelium bursting through the epidermis of the leaf; c, summer spores arising from apex of a resting spore case; d, summer spores, (conidia) one germinating; e, section of a spore pustule (spermogonium) produced in summer; f, section of resting or winter spore case, (perithecium) found in tissues of old diseased leaves which have lain on the ground over winter; g, a spore sac (ascus) containing eight two celled winter spores; h, a winter spore (ascospore) very highly magnified. (Original.)

This is the most common and important of the fungous diseases of the strawberry. It attacks the leaves causing at first purple spots which gradually become lighter in the center until they finally stand out clearly against the green background of the leaf as rounded, light colored spots surrounded with a brownish-purple border. Although these spots are not large they often run together sometimes covering a large part of the leaf. During the summer the spots give rise to minute tufts of spore-bearing stalks. The spores given off by these are capable of spreading the fungous parasite during the growing season.

Badly affected leaves die during summer and in their tissues minute, black bodies (perithecia) develop during the latter part of autumn. These bodies, which are the resting-spore cases, are situated just under the epidermis of the dead leaves but possess a projecting mouth which opens outside the leaf. On the interior of these spore cases may be seen with the microscope many very small spore sacks (asci) each containing eight two-celled spores. These spores are not mature until in spring, at which time they are capable of starting the disease on the new foliage.

Treatment should consist of spraying with some reliable fungicide, when the new foliage is appearing in spring, with a second application when fruit is setting, to be repeated after harvesting the fruit if the plantation is to be kept. Mowing and burning the leaves after the fruit is gathered, has been found to reduce this disease by destroying the old leaves in which the fungus hibernates.

WOUND FUNGI.

Among the numerous fungous inhabitants of the orchard are a number of so called wound fungi. While ordinarily existing as saprophytes, living in the dead tissues of the trees, these fungi may under favorable conditions assume the role of true parasites and cause the death of living portions of their host. As the name implies such fungi gain an entrance into the roots, trunk or limbs of a tree by means of wounds. The wounds may be of various origin, such as those caused by hail, "sun scald," splitting at the crotches from strong winds or the weight of snow, ice, or heavy crops of fruit; injuries caused by animals pastured in the orchard, and bruises made while plowing and cultivating among the trees. Improper times and methods of pruning also make it possible in a great many cases for the establishment of wound parasites. Fig. 41 shows the trunk of a tree one side of which has become inhabited by a colony of several kinds of these wound fungi. They first gained an entrance through extensive ruptures of the bark due to sun scald. The spores of these fungi, falling into the crevices thus formed, have found a favorable place to grow, and, while at first the exuding sap and dead cells of the inner bark served to nourish the young mycelium, the trunk is now being slowly invaded, the water circulation impeded or cut off in some places, and the trunk weakened by the rotting of the wood. While such trees often live and bear fruit for a number of years they gradually fall into a condition of unsightly decay and eventual death. Very often the end of a large branch which has been left too long in pruning and without a protective coating gives entrance to such fungi. In such cases the trunk is frequently hollowed out in time by the decay of the heart wood with a

Fig. 41.—A colony of wound fungi following an injury by sun scald on trunk of cherry tree. a, b, spore bearing organs, (sporophores) of two different fungi.

Fig. 42.—Part of branch from Keiffer pear affected with a wound fungus (Polystictus versicolor Fr.) The branch is yet alive and has produced fruit buds but the heart wood is soft and rotten. (Original.)

convenient opening left for the birds and squirrels. Such trees are apt to yield to the force of storms especially when loaded with fruit.

Most of the fungi which act as wound parasites belong to the pore-and-gill-bearing fungi many of which are of considerable size when in fruit. The following species have been noted by the writer as occurring on trunks and limbs of fruit trees:—

Polystictus versicolor.
Polyporus adustus
Polyporus resinosus.
Fomes leucophaeus.
Fomes igniarius.
Irpex sinuosus.
Schizophyllum commune.
Collybia velutipes.
Pholiota adiposa.
Pleurotus ostreatus.
Pleurotus areolatus.

PREVENTIVE MEASURES.

The manner in which these fungi gain an entrance into the trunks and limbs of trees, namely through wounds, suggests the importance of treating all extensive ruptures of the bark with some protective coating. This is especially needful in the removal of large limbs. In such cases the natural process of healing over is often not accomplished for a number of years and during the process some wound fungi are pretty certain to gain a foothold unless measures are taken to exclude the spores. This is most frequently accomplished by painting or coating the cut surface with some good paint, hot tar or liquid wax. The cut should be made close to the main branch or trunk in pruning thus favoring quicker healing and avoiding stubs which die at the end and invite the attacks of these wood-destroying fungi. Lower branches which are shaded too much, as in crowded and unpruned orchards, are constantly dying back for want of nourishment. In such cases the dead portions fall a prey to wound fungi which may in time reach the main branches and trunk. Such dying limbs should be removed and the wounds covered. Where decay has begun in the trunk it is often difficult to prevent its progress. If confined to a limited portion of one side the decaying wood may be cut out as far as possible, the surface treated with a strong solution of copper sulphate and coated with tar, to be renewed as often as necessary. Removal and burning of the fungous outgrowths will also prevent the formation of spores.

INJURIES OF FRUIT TREES NOT DUE TO THE ATTACKS OF PARASITES.

Among the so called mechanical injuries of fruit trees and other plants are some of quite common occurrence. In most cases they are due to sudden changes or unusual degrees of temperature and affect mostly such plants as are not quite hardy.

"Sun Scald" is a term usually applied to injuries of the trunk and larger branches of trees arising from the killing of the inner bark and cambium by the action of the sun's rays. The south and west sides of trunks are usually affected and young trees are more subject to injury than old ones. The injury often occurs late in winter and early spring, especially when clear warm days are followed by severe cold at night and especially if growth has been prematurely started. The same trouble may arise also in summer on exposed trunks and limbs. The injury is characterized by the splitting and loosening of the bark which often becomes entirely detached. Sun scald offers a favorite place of entrance for wound fungi which sometimes cause the death of the tree. (See Fig. 41.)

"Frost Cracks" arise from the combined action of sun and severe freezing leading to longitudinal ruptures or cracks in the bark and wood. They usually occur, as does sun scald, in trees which have made a late autumn growth and which enter the winter with the tissues full of water and improperly matured. Peaches, plums and cherries, especially the sweet varieties of the latter, are more subject to these injuries than are apples and pears.

Prevention of these two injuries can be secured only by protecting the trunks from the direct rays of the sun by means of burlap, straw or other wrapping or shading devices, and by inducing the trees, so far as possible, to thoroughly mature their wood before winter sets in. The latter aim may usually be realized by the use of the proper fertilizing elements, as potash, in the soil, and especially by the use of cover crops sown late in summer, to utilize any excessive moisture which the soil may contain at this time and thus induce earlier maturity of the trees.

"Sun Scorch" of foliage is, as its name imples, due to excessive heat of the sun on foliage of plants deprived of a sufficient water supply as during a drouth. The occurrence of hot, dry, winds especially on tender foliage also produces a similar effect. This trouble has been noted on foliage of cherry and maple trees especially where situated on shallow soils with underlying rock. While hardly under the control of the grower the proper location of orchards accompanied with constant stirring of the surface soil to retain moisture should be considered as partial preventive means.

"Two unusual troubles of apple foliage" have been noted in New York, the first being "frost blister" and the latter the spotting of foliage caused by spraying. The first injury was due to heavy late frosts occurring while the foliage was still very young. The damage, however, was considered unimportant, and of course beyond control.

Injury to foliage of apples by spraying was noted as quite general in

New York during the summer of 1902. The foliage appeared spotted and yellowed and eventually fell off. The trouble was not considered as due to the use of improper spraying materials so much as to the tender condition of the foliage during that season induced by the protracted cold, wet weather.

Occasional injuries of this nature should point to the use of proper care in spraying methods and not to the abandonment of spraying.

SPRAYING AND SPRAY MATERIALS.

From the time of the discovery in France in 1883 that a mixture of lime and copper sulphate, applied with a whisk broom, would check the ravages of the downy mildew of the grape, to the present use of fungicides, applied with powerful pumps and perfected spraying nozzles, a long stride has been made in the prevention of plant diseases. And yet at the end of twenty years, during which a great many formulas have been devised and tested, copper in some form still retains its place at the head of the list of fungicides. Moreover the combination of copper sulphate with lime first used, and which soon became known as Bordeaux mixture, is still the most popular and widely used preparation of the copper salts.

The chief value of a spraying mixture lies in its ability to prevent the germination of the spores of the parasitic fungi causing diseases. Thus a condition of immunity is secured to the plant while it is covered with a layer of the fungicide. The salts of copper which have been found to be preeminently fungicidal owe their extensive use in this line to the fact that when they are present, even in seemingly insignificant amount the spores of fungous diseases are either prevented from germinating or killed when germination begins. Sulphur, both free and in the form of powder or in combination with other elements, is also capable of checking the action of the surface mildews for which purpose it has long been used.

In order that the best possible results may follow the use of any spraying mixture, the following conditions should be aimed at,—1. The fungicide should be the one most effective for the prevention of the disease to be combated. 2. The spraying mixture should be harmless to the foliage and other organs of the plant treated. 3. It should be applied so thoroughly as to cover the vulnerable parts of the host plant with a uniform but thin and continuous layer. 4. Mixtures used on ripening fruit should not detract from its appearance and consequent market value. 5. As a rule fungicides should not be used when the plant is in bloom.

Bordeaux mixture, as already stated, has been found to be the most effective general fungicide in use. Its value lies not alone in its immediate fungicidal property but also in the fact that the copper salt which it contains is but slowly soluble thus causing it to retain this property for a considerable period after it is applied. The materials of which it is composed are cheap and readily obtainable and its preparation, while requiring care, should not be beyond the capabilities of any fruit grower.

While the Bordeaux mixture is primarily a fungicide it has also been found to possess some value as an insecticide. One of the desirable fea-

tures of this mixture is the fact that it may be combined with Paris green which is the most common poison for combating leaf-eating insects. Thus two enemies may be fought with one spraying mixture. (See Bul. No. 224.)

FORMULAS.

BORDEAUX MIXTURE.

"Normal," or the 1 to 10 formula:

Copper sulphate	4 pounds
Quick lime	4 "
Water	40 gallons

The amount of water may be varied from 40 to 50 gallons, while for peaches 60 gallons of water should be used. The amount of lime may also be slightly increased, if the mixture shows a tendency to burn the foliage or roughen the fruit.

Preparation.—The copper sulphate may be dissolved by means of hot water and then diluted in the proportion of two gallons of water to one pound of the salt. In preparing large amounts it is customary to place the copper sulphate in a coarse sack which is then suspended in the upper part of a barrel of water and left until dissolved.

The lime should be fresh quicklime. If this cannot be obtained double the amount of air slaked lime may be used but it is not considered so good and cannot be recommended. Slake the lime in the usual manner as in the preparation of whitewash, adding water slowly. This should then be diluted with water, after previous straining through a fine sieve or piece of coarse sacking. The two solutions are now to be mixed under constant stirring, while pouring the two liquids together, after which water is to be added to make the full amount. The more dilute the solutions are when mixed the finer will be the resulting precipitate. On the other hand, if the copper solution and the lime are concentrated, the precipitate will be coarse and heavy and is apt to clog the spraying machinery. Furthermore, the mixture when prepared with strong solutions requires more constant stirring during use to prevent settling and consequent unevenness of application. A stock solution of the copper sulphate may be made of known strength (i. e. one pound to the gallon), and kept in closed vessels and diluted when wanted. The lime may also be slaked in large amounts and if covered with water will keep for a considerable period.

The proportions of copper sulphate and lime as given, ordinarily produce a mixture which is slightly alkaline and consequently harmless to the foliage of plants. It is safest, however, to test the mixture before using it to make sure that the acid of the copper sulphate has been entirely neutralized by the lime. A reliable test consists in the use of the yellow prussiate of potash (ferro-cyanide of potassium) which may be purchased at any drug store. One ounce of this salt dissolved in half a pint of water will constitute the test solution. To apply the test a little of the Bordeaux mixture is put in a white dish and a few drops of the ferro-cyanide solution added. If a brown discoloration results more of the lime milk is to be added to the mixture until the test solution remains colorless when applied. Another test consists in dipping a clean piece of polished iron or steel, as a knife blade, into the mixture for one minute, when a delicate coating of metallic copper will be deposited on the iron

if there is not enough lime present. A piece of red litmus paper may also be used by dipping it into the mixture, if it remains red more lime is necessary while if it becomes blue the mixture is alkaline and may be safely used.

BORDEAUX MIXTURE WITH PARIS GREEN.

Paris green, which is the most common material for combating the codling moth and other leaf and fruit-eating insects may be combined with Bordeaux mixture thus reducing the labor and expense in spraying for both fungi and insects. (See Mich. Exp. Sta. Bul. No. 224.) It may be used at the rate of one pound to 200 gallons of the mixture.

SODA-BORDEAUX; HYDRATE.

Babbit's Potash or Lye or Lewis' Lye,	Soda	1 "pound" can
Copper sulphate		3 pounds.
Lime		5 ounces.
Water		30 gallons.

Dissolve the copper sulphate in about five gallons of water and the soda or lye in ten or twelve gallons. Pour the soda solution into the copper solution while stirring. When about two-thirds of the lye solution has been added test with red litmus paper and cease to add any more of the alkali as soon as the paper turns blue. Then add the lime previously slaked and diluted, after which water is to be added sufficient to bring the mixture up to 30 gallons.

This fungicide was first used in 1895 by Prof. Halsted of New Jersey, who has given it subsequent trials with very satisfactory results. The small amount of lime which it contains gives it considerable advantage over the ordinary Bordeaux mixture in the ease of application and the almost total absence of any unsightly coating, hence it is adapted to use on fruits just before maturity.

Persons who use Soda-Bordeaux for the first time are advised to make a thorough test upon a small scale, with one or two plants, before the application is made general.

SODA-BORDEAUX WITH PARIS GREEN.

It has been satisfactorily demonstrated that Paris green may be combined with Soda-Bordeaux even to the extent of one pound to one hundred gallons, "a much higher percentage than is usually employed," without harmful effects on foliage.

COPPER SULPHATE SOLUTIONS.

(STRONG)

A.	Copper Sulphate	1 pound.
	Water	25 gallons

This strong solution is for use on trees and shrubs before the leaf buds open in spring. After the leaves appear it should not be used as the foliage would be killed by it.

(WEAK)

B.	Copper Sulphate	1 pound.
	Water	250 gallons.
C.	Copper Sulphate	1 pound.
	Water	400 gallons.

The above solutions are recommended by Professor Taft as being very servicable and safe. No. B may be used without danger to the foliage of any except the most tender plants. For the peach and equally tender kinds the No. C solution may be used. These solutions possess the advantages of easy preparation and application and do not discolor the foliage and fruit as does the Bordeaux mixture. They may therefore be used when the fruit is maturing and in the latter part of the season when the foliage is less tender.

AMMONIACAL SOLUTION OF COPPER CARBONATE.

CUPRAM.

Copper carbonate	1 ounce.
Ammonia—Enough to dissolve the copper.	
Water	12 gallons.

Dissolve the copper carbonate in the ammonia with constant agitation. This may be kept for a considerable time, in stoppered bottles and when wanted diluted with the proper proportion of water as given above. The strength of ammonia as generally obtained is apt to vary considerably. The strength usually recommended is the 22° or 26° Baume. If these are used a less amount is required than that generally sold, otherwise the preparation is the same.

A modified form of the above solution may be prepared by using

Copper Sulphate	2 pounds.
Carbonate of Soda (Salsoda)	2½ pounds.

Dissolve each salt in two gallons of water then mix. The copper is precipitated in the form of carbonate and if allowed to settle may be collected and dried after pouring off the water. Or enough ammonia may be added to dissolve the copper carbonate and diluted with water to 40 gallons.

Prepared in either of the above ways this solution is a clear blue liquid. It is especially suited to spraying plants which are maturing their fruit as it leaves no conspicuous stain. Besides it possesses high value as a fungicide.

This solution is not suitable for combining with Paris green and other arsenites without the addition of lime in amounts two or three times that of the poison.

NOTE.—*Neither iron, nor tin vessels should be used in preparing solutions containing salts of copper.*

POTASSIUM SULPHIDE SOLUTION.

Sulphide of Potassium (Liver of sulphur)	1 ounce.
Water	3 gallons.

The sulphide dissolves readily and forms a clear solution suitable for combating the powdery mildews especially on the gooseberry. The solution should be freshly prepared before using as it does not keep well.

GENERAL SPRAYING RECOMMENDATIONS.

While treatment has been suggested in connection with the description of each disease mentioned in this bulletin, some general suggestions for spraying are here given in such form as to enable the grower to determine more readily when and how often to spray. These recommendations are intended to cover the needs of the plant in case of attack by any or all of the diseases most common to it but the grower's judgment should at all times be exercised in the matter. Thus in some cases the number of sprayings may be fewer than those here given depending upon the prevalence of the different diseases. In some cases it may be advisable to repeat a spraying at once as in the event of a heavy rain that washes the fungicide from the plant. On the other hand, if the plant is already well coated with an effective fungicide there will be nothing gained by adding more.

Fungicides and insecticides can usually be combined and applied at one operation thus reducing the labor and expense in combating both enemies. (See Michigan Experiment Station Special Bulletin No. 24.)

APPLE.

1. Before buds open use copper sulphate solution A.
2. Just before blossoming use Bordeaux (with an insecticide).
3. About a week after blossoms fall, with same preparation as No. 2.
4. Ten days or two weeks later, repeat 3. (Sometimes omitted.)
5. About August 1 for late varieties, repeat No. 2.

PEAR.

Spraying recommendations for the apple may be followed; use copper sulphate solution B for last application, if necessary. Cut and burn all branches affected with twig blight as soon as it appears, cutting 6-10 inches below the diseased portion. Repeat this in autumn before leaves drop.

QUINCE.

Follow the general directions for pear, omitting, perhaps, the No. 5 application.

PEACH AND APRICOT.

1. Before April 1st, copper sulphate solution A.
2. After fruit sets, Bordeaux mixture, two-thirds strength (with an insecticide).
3. Ten days or two weeks later, repeat No. 2.
4. In case of brown rot, use copper sulphate solution C.
5. Repeat No. 4 about once a week if rot continues.
6. Watch for "yellows" and "little peach," digging out and burning as soon as recognized.

PLUM.

1. Cut off and burn all black knot. Before buds open, use copper sulphate solution A.
2. When fruit has set, use Bordeaux mixture (with an insecticide).
3. About two weeks later repeat No. 2.
4. At intervals of two or three weeks, repeat No. 2, if necessary.
5. When fruit is about three-quarters grown use copper sulphate solution B.

CHERRY.

1. Follow the general directions for the plum.

GRAPE.

1. Before buds open, use copper sulphate solution A.
2. When leaves are about half grown use Bordeaux mixture (with an insect poison).
3. Ten days or two weeks later, repeat No. 2. Use potassium sulphide solution if powdery mildew appears.
4. After ten days or two weeks, repeat No. 3, if necessary.
5. When fruit approaches maturity, use a clear fungicide if needed.
6. If mildew persists, after harvesting, use Bordeaux mixture.

RASPBERRY AND BLACKBERRY.

1. Cut out canes badly affected with anthracnose and insects. Before buds open spray with copper sulphate solution A.
2. After new growth is ten or twelve inches long, use Bordeaux (with an insect poison). Dig out and burn plants showing orange rust.
3. At intervals of one to three weeks, repeat No. 2. Use a clear fungicide before fruit ripens to avoid stain.
4. After fruit is gathered remove old canes, spray with Bordeaux.

CURRANT.

1. When leaves are well out and as soon as leaf-spot appears, use soda Bordeaux or ammoniacal copper carbonate.
2. After fruit is gathered use Bordeaux.
3. If leaf-spot continues, repeat No. 2.

GOOSEBERRY.

1. Before buds open, use Bordeaux (with insecticides).
2. When fruit is formed, use potassium sulphide if mildew appears.
3. When necessary, repeat No. 2.
4. After fruit is gathered, use Bordeaux if needed.

STRAWBERRY.

1. Just before blossoming, use Bordeaux (with insecticide).
2. After fruit sets, copper sulphate solution B.
3. After harvest, if to be kept, use Bordeaux.

New plantations during first year should be given treatments No. 1 and No. 3.

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